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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION X:

Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

REPORT No. 2

(All countries except Spain, Portugal, France, Great Britain, its Dominions and Colonies, Belgium, Luxemburg, Holland, Denmark, Norway, Sweden, Finland, Germany, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey and Poland),

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Foreword.

The different questions relating to the staff of the railways were considered by the Congress as early as at the Milan and Paris Sessions in 1887 and 1889. The discussions that took place then were extremely interesting and complete : not only was the importance of the moral and material means, by which the necessary union between the management and the employees was maintained, recognised, but also the special value of premiums for economies by bringing into play the personal interest of the staff itself, which is one of the best means of developing their efforts towards obtaining an improvement in the operating results.

Forty years later the same objects were again discussed at the Madrid Congress and the interesting reports drawn up for that occasion on the subject of professional training, employment of mechanical methods in office work, and the participation of the staff in the working and the operating profits were, without any doubt, an appreciable help towards the study of the problem.

In the course of the discussions at Madrid, the desirability was recognised of again including the subject in the agenda of the next Congress by incorporating the question of the participation of the staff in the profits in the more general question of the scientific organisation of work in the departments of the railways.

Set in this way, the problem was obviously more interesting and any study of it should aim at including all its multiple and complex aspects, technical, financial, social, so as to get as complete a synthesis as possible.

It was however easy to be persuaded that such a study would require a great deal more time than the Reporters for the Cairo Congress could devote to it, and also that it should have been undertaken at a less difficult time than the present so that the different Railway Companies questioned could have considered the matter in the quiet way needed.

The result was the contrary, as in the midst of the urgent cares of the day, many companies were not able to reply to our questionnaire, or else politely informed us that they could not give the time needed to study the matter. The few who did answer did not point out or report to us any concrete cases of scientific organisation of work and contented themselves with giving information about proposed schemes on other points.

In general it can be said that the data we received was not in proportion to the importance of the question. Consequently the Italian Reporters on Question X found it necessary to nearly limit their study to the information supplied by the Italian State Railways which alone was sufficiently detailed.

* * *

After a rapid survey of the general organisation which, with a few small and unimportant differences, is practically common to all the companies who replied to our questionnaire, the report deals with :

1. Some important applications of the scientific organisation of work, the object of which is to exercise an efficacious control over the different working activities, and over the use of the equipment and of the staff;

2. Some special systems of remuneration co-ordinated with some suitable organisation of the work in order to make the staff directly interested in increasing its individual output and lessening expenses;

3. Measures intended to improve morally and materially the condition of the staff and which help to attach it more closely to the undertaking.

I. — General organisation of railways.

Nearly all railway companies are made up of several head offices which deal with specialised branches of the company (Permanent way department; Traction and rolling stock department; Traffic department) or with general questions (Staff; Finance and Accounting departments; Stores). According to the extent of the railway and the importance of the traffic there are a larger or smaller number of divisional organisations which control the local services and in their turn are composed of offices that have to deal with specialised branches of the undertaking and others dealing with general questions.

The co-ordination of the headquarters departments is generally assured by the President or the General Manager of the Company; that of the outside departments by a higher official (in the case of the American railways, the Superintendent; in the case of the Italian railways, by the Head of the department).

As far as the specialised branches are concerned, the divisional offices are controlled on uniform lines by the corresponding head office; as far as general questions are concerned, these are decided by the Heads of Departments who remain in close contact with the general management.

In the case of the United States Railways, among the head offices, the Commercial Services are held in great esteem, as it is thought with good reason that much of the financial success of the company depends upon their spirit of initiative. The Italian State Railways have recently set up a special department, the Commercial Services, much of whose work was formerly done by the Train Working Department. The particular importance of the Commercial Services at present is largely due to the need for studying the problem of the competition of more recent methods of transport.

Many, if not all Railway Companies, have adopted the plan of handing over to private firms either partly or wholly some of the services closely connected with the working of the railway.

Such services are more especially those dealing with the upkeep of the rolling stock, the permanent way, and certain special equipment (elevators, cranes, clocks, weighing apparatus, etc.). In many cases the cleaning of the stations and warehouses, etc., the disinfection of wagons, the handling of fuel at the coal dumps, the loading and unloading of goods, etc., is placed in the hands of private firms.

The Italian State Railways in addition to the above-mentioned services have recently developed the system of renting out the working of small stations to private firms (*Assuntorie*).

Out of the stations owned by the State Railways which approximately number 3 100, about 1 000 have been let out in this way and are managed by private firms.

This has generally given good results : it makes possible a reduction in the permanent staff, reducing thereby the general working expenses and the cost of pensions, the cost of contributions to the clothing funds, etc.

Furthermore, in the case of these firms, the number of the staff is always proportioned to the amount of work to be done and it is possible to arrange for the amounts of wages paid to correspond more closely with the work done than is the case when this same work is done by the administration itself.

The Administration of the Italian State Railways is in consequence favourably disposed to extend this method within certain limits which vary according to circumstances and localities.

Many Railway Companies, on the other hand, directly carry out many functions which are not directly part of their real activities, but which have a more or less distant connection with them, such as

the transport of goods by ferry-boats, certain road motor transport, the construction of new rolling stock, the management of hotels, etc.

The carrying out of such functions as these is chiefly due to the local conditions of the railways in question.

II. — Application of the scientific organisation of work in the administrative sphere.

The General Management of the Italian State Railways has studied and introduced a system of book-keeping which, while making it possible to carry out all accountancy and statistical work more rapidly and more economically, also enables the Management to gather together and co-ordinate all the elements it needs in order to exercise its proper functions of supervision of the general working of the undertaking and of controlling the executive departments both individually and as a whole, with the common object of achieving regular and economic working.

The system is based on the following organising principles :

Simplification, standardisation and rationalisation of the basic documents;

Centralisation and mechanisation of accounting and statistical operations;

Establishment of an organic plan of sorting out the elements obtained in view of their subsequent utilisation as needed by the general or divisional headquarters.

The work done by the system we have just described is chiefly concerned with the determination of :

1. The work of locomotives and enginemen;
2. The regularity of the locomotive and train working;
3. The cost price of the work and the output of the workmen in the main repair works, in the depot repair shops and in the running repair shops;
4. The use and the supply of materials;
5. Passenger and goods traffic for each line, and goods traffic according to the goods classification and to the rates headings.

The basic documents from which the elements needed for a summary of all the statistics needed for this enormous entity of work (with which we will deal later on) have been reduced to the following :

Driver's statement . Guard's statistical statement	accompanying each train.
Waybill *re* the transport of goods . . .	accompanying all transport of goods.
Works order for work carried out in the shops	for all work carried out in the main shops or in the depot repair shops or in the running repair shops.

Time card of the workmen employed on the above-mentioned work.

Stores issues and receipts; tickets and invoices	for all operations relative to the movement of materials.

These documents are transcribed onto cards (of the perforated type) which, when subsequently handled by the now well-known machines, make it possible to get mechanically all the data needed for the various accounting and statistical operations.

The cards are made out partly at the divisional offices, partly at central headquarters and a programme for the gradual and complete centralisation of these operations has been drawn up.

The cards are collected together and worked up at headquarters which carries out the actual sorting out of the cards and sends the various results obtained to the offices concerned.

A. — *Determination of the work done by and the use made of locomotive and train staff.*

This work, as far as the accounts are concerned, deals with the settlement of

the additional allowances of the train staff (about 16 000) and, as far as statistics are concerned, the determination of the work done by each locomotive in service (about 5 000).

Whereas with the old clerical system 250 men were employed, with this new method 190 are sufficient, a saving of 21 %, and futhermore it is possible to bring out new statistical elements which previously it was not possible to think of getting, owing to the cost.

Actually, all the statistical elements relating to the mileage of trains and the tonnage carried for each line, which previously were not collected, because to have done so would have necessitated the employment of many clerks, are now, without increasing the number of clerks employed, collected monthly and are very valuable material for comparisons and investigations; amongst these are those that bear upon the question of the expediency of electrifying lines at present worked by steam locomotives.

The bringing together of elements which serve in determining the work of the locomotives and the staff has been so arranged as to make it possible to get at the same time information on the average weekly or monthly utilisation per member of the staff, per category of staff (drivers, firemen, or relief men) and per depot.

This systematic control facilitates the determination of the requirements, the study and the revision of the turns of duty of each unit, or a different distribution of the services among the various units of the railway.

The general management has decided that the exact and systematic control of the work of employees of this category of the staff is of particular importance because of the greater difficulties of utilising them in practice and the greater expenditure involved in comparison with other categories of the executive staff.

In consequence of the good results obtained, a study of similar organisations of control for other important categories of staff has been undertaken.

In the different sections the runs worked over the heaviest gradients on the most important lines have been chosen; for each of these and for each train a perforated card is made up. The different sectional offices, where the cards are perforated, send the cards every month to headquarters where by means of sorting and tabulating machines two tables are drawn up per run :

1. a table for each train every month;
2. a table for each day of every month.

These tables are carefully gone through by the central office which deals with the management of the depots, the timetables, etc. The verification of these tables has given satisfactory results; based on the data obtained, the general management has been able to apply a series of measures which beneficially affect the costs of working, in the period before the decline of traffic.

B. — *Control of the running of fast and express passenger trains and perishable goods trains.*

Formerly the general management based its control on tables drawn up by the divisional offices, but this proved to be too slow and ineffective.

Thanks to the system now in use, the divisional offices send up to the general management the cards prepared from the original documents that accompany each locomotive and deal with each train, and the central office is able to ascertain, as regards train numbers, operating difficulties and causes of delay, the working of each train both daily and monthly.

800 trains are controlled in this way, and this control makes it possible to eliminate very quickly the systematic causes of trouble and to perfect regularity of working to the utmost limit.

C. — *Accounts and analytic statistics of workshop expenses.*

The abstract of the time employed for each kind of work and the control of the attendance of employees are obtained by means of time recorders with individual cards placed in each working section.

These cards, one for each employee, are stamped with the name of the holder every month by means of printing machines and are kept in a special card rack provided at each recorder.

The front of these cards is divided into four parts : in the two central ones, the in and out times are stamped and these are used to determine every day the presence or absence of the men; in the two side parts are printed the times from which the time taken over each task is calculated.

On the back of the sheet is stated in detail the time spent each day on the different kinds of work.

Each employee has to keep the work order he is engaged on in a special case so that the foremen and management can always verify whether he is doing the required work properly.

As soon as the work on the current order is completed and the employee has got it passed, and has received a new work order, he gives these two orders to the employee charged with the distribution, who by means of the time recorder, marks on the work card the time at which the work was changed, indicates the time taken for the completed work and the times allowed for the new order on which he marks the number and name of the employee who then goes back to his work.

The orders carried out, completed by the indication of the time spent on them, are sent to the accounting office of the shop, which sees to the settlement of the premium, the determination of the cost of labour and the amount of general charges to be allotted.

Also the accounting office daily receives from the shops the inwards and outwards stores notes for material on which notes the same office enters the proper share of the amounts of each order.

The individual cards, completed by statements of the reasons for non-attendances and details of the way the time of attendance was employed, are sent up at the end of the month to the accounting office which checks them and sets out on each the total of the amounts due as premiums on work done, for absences with pay and for possible duty away from the shop.

The work orders, stock statements and attendance cards form the basic elements from which the pay sheets of the staff or the determination of the cost price are prepared.

The accounting offices of the shops are provided with perforating machines. After the basic documents for the accounts have been checked and completed, the following cards are perforated :

— as many cards as there are motives of absence on the individual cards;

— one card for each work order;

— as many cards as there are classes of materials, kinds of orders and vehicles concerned, for each stores issue ticket, stores receipt ticket, or for each ticket for material passing through.

The perforated cards are sent monthly to general headquarters where are extracted the following tables which are then sent to the shops for the subsequent operations of payment, invoicing and the compilation of the general budget of the shop in question.

The first table shows, in the order of the number of the employee or of the document, absences and work orders respectively, with the production or economy premiums, as well as the general totals of each of these headings.

A second table includes, by order of number, document and technical section, all the operations in the stores depart-

ment, transfers, payments and miscellaneous accounts, with the totals under each heading.

In this way two clear and orderly records of all documents concerning the accounting are obtained which are easy to consult whenever there are investigations or verifications to be made.

On another table, under each class of material, the amounts loaded in and out with their respective totals are set down. This serves to control the registration of deposits made by firms and to follow the consumption of stores.

For each element of the rolling stock, or for each part of the vehicle that it is desired to stress, for each kind of work and for each order, special tables are drawn up from which all the price elements can be got, both on the debit and on the credit side.

With the object of following up absences, another table, from which a graph is afterwards made, is drawn up, which shows absences subdivided by motives with the respective totals.

Finally any other tables required periodically or occasionally for accounting or statistical purposes can be drawn up.

The results obtained can be briefly summed up as follows :

As far as control apparatus is concerned :

— the technical supervising staff is freed from the clerical work which might possibly interfere with its main work;

— the possibilities of mistakes and reclamations on the part of the staff concerned are decreased;

— all the staff is interested in avoiding loss of time between the end of one task and the beginning of the next;

— the managing staff has every facility for making sure that each employee is doing the work required of him.

Furthermore, without increasing the clerical staff, it has become possible to carry the analysis of the cost to the maximum extent desired, and to extract and summarise data which in spite of their value for comparisons and investigations could not be worked up formerly on account of the great expense entailed.

D. —*Stores department accountancy.*

Three principal objects were aimed at by the new organisation :

1. to assure the perfect functioning of the stores accounting which the central administration is better able to deal with in exact fashion than the divisional organisations;

2. to exercise a direct and more efficacious control over the work of the stores or depots depending thereon, by following day by day their activities through the individual documents which show the different operations carried out;

3. to put at the disposal of those responsible for stores in a direct and immediate fashion precise information on the stock in hand, the consumption and the position of each kind of material so that they may have at their disposal all the information needed to enable them to build up the stock in good time and in quantities corresponding to the actual needs; to regulate the issues so as to avoid accumulations of stocks in one place and shortages at another; to obtain their proper utilisation and economy in transport; finally, to call attention to any material that by reason of changed conditions no longer answers to requirements, or is in excess of requirements, so as to assure their disposal under the best possible conditions or even their reutilisation after the necessary alterations have been made.

The shops and depots of the railway daily collect together and forward to headquarters all the documents they have issued. There these documents are divided as between groups of employees

for the application of prices and the checking of all the numerical information which should be entered up on the cards.

From these cards all the information needed for the stores accounts can be obtained, for example as regards *receipts :* abstracting the invoices for purchases and manufactured parts, issue of materials worked up in the shops, obsolete stock or surplus, movements of stock as between the different shops, transfers and ajustments; for the *issues :* abstracting the issues to the shops of materials needed for repairs to rolling stock, of stocks, of general consumption of material in excess on the inventories, sales, adjustments, etc.

Over and above there are drawn up : tables showing the receipts and issues of each kind of material, by classes and showing first the receipts and then the issues; the movement of new stores as distinct from that of rough materials or used stock which is still useful; the operations in connection with the handling of each class both on receipt as on issue, arranged in chronological order and progressively, according to the nature of the document which facilitates in particular checking and the search for mistakes which may have occurred.

Results relating to the movement of stock are entered into the accounts; all the rest are used for the establishment of debits and credits for the different services and for the recapitulative accounts of the budget.

Registration is made under each heading on a special current account wherein as well as the precise nature of the stock is set down the number and category, quantity and unit price, remaining quantities and their value at the end of each financial year, the receipts during the current year, the issues and the quantities in hand every month.

Owing to the registration of the movement of stocks being thus arranged, it becomes easy to establish at any given moment a statement showing the stock and consumption in each stores and depot, and furthermore to pass on to the organisations responsible for purchases of materials or using these, all information concerning fluctuations in prices, the movement of usable old stock or of scrap, and in general about those materials the use of which, owing to special circumstances, undergoes appreciable variations. It is possible moreover to supply those interested with information of a statistical nature to assist any investigations found necessary in connection with the management of the stores.

The stock accounts thus briefly described sum up the movements of 28 stores, 276 fuel depots, 27 maritime agencies and 7 land agencies, the figures for which amount to 120 000 items a month; they are kept by rather less than half the number of employees formerly needed.

A useful addition to the card system adopted for accounts consists in the use of metal furniture of the Kardex type fitted with card carriers with visible headings which makes it possible to read the titles very quickly, these being revealed as soon as the drawer is opened.

On the outside of each drawer is the title and number of the category of stores with which the ledger cards kept therein deal. The filling cabinets are divided into groups above which is a descriptive label indicating the corresponding grouping of the materials. This brings orderliness into the office where the analytical recording of the whole of the enormous mass of materials supplied to all the stores and depots is carried out, whereby anyone having to make an investigation can at once find his way and have some chance of finding what he needs without delay.

After four years practical experience of this system it can be said that the results obtained have met requirements.

The General Management, by means of the checking of the papers, has been

enabled to follow day by day the activities of each store and by preparing statements of the stocks regulate the utilisation thereof, and determine exactly what stock is required when it is a question of fresh supplies.

E. — *Passenger and goods traffic statistics per line.*

The General Management for some years has arranged for special forms to accompany each passenger train or each consignment of goods, on which forms are shown the various parts into which the journeys over each line are divided for statistical purposes. The train staff records for each such journey the number of places available in the train and the seats occupied in each class as well as the weight of luggage carried and the goods loaded on passenger as well as goods trains.

The information given in these documents makes it possible to calculate and sum up the monthly traffic of the different lines, expressed in passenger-kilometres and ton-kilometres of luggage and goods (divided into consignments in complete wagon loads or made-up loads).

F. — *Abstract of the railway's goods traffic, classified according to nomenclature headings and classes of rates.*

Such information is obtained from the waybills and from the corresponding summary of the characteristic traffic data.

G. — *Other less important kinds of work.*

These kinds of work which are always carried out by means of the same machines and perforated cards are : accident statistics, the staff records of the entire railway, and the rolling stock inventory. We think it would be useful to consider the latter for a moment.

The technical-numerical inventory of the rolling stock, including stock withdrawn in the period 1929-1930, contains in all about 200 000 cards approximately divided up as follows :

6 000 cards — steam and electric locomotives;
5 000 cards — parcels and mail vans;
9 000 cards — carriages;
180 000 cards — wagons.

The cards classified according to type of stock (steam locomotives, electric locomotives, carriages, parcels vans, mail vans, covered wagons, open wagons, tanks) show the following characteristic numerical information :

— the service number;
— year of construction;
— original value;
— weight when empty;
— class of speed;
— wheel base;
— number of compartments;
— length and capacity;
— maximum load;
— floor length.

Further information supplied in code because expressed in conventional figures or groups of figures concerns :

a) for steam or electric locomotives, supplementary fittings, brake, lighting, speed-indicator, lubricators, sand-gear, trolleys, control gear, motor and generator, cylinders, valve-gear, blast pipe, connecting and coupling rods, nature and frequency of the current supply, the power units, the source of supply, etc.;

b) for carriages, parcels and mail vans, the series and class, brake, electric lighting, type of wheels and axles, the interior arrangement;

c) for wagons, the series, body frame, form and construction of the body, type of sides and whether fixed or hinged.

The whole of the technical and numerical information given on the cards for the different types of rolling stock makes it possible to extend the field of enquiries to limits that could not previously be attained except in a much less exact method and with a considerable

loss of time due to the difficulty of the calculations and verifications.

A very large and extensive mass of information is thus established which is arranged in an easy and sure method for handling, capable of giving rapidly and exactly all the combinations and groupings desired for the complete knowledge of either the whole of the traction units considered as regards the power and efficiency of the different groups constituting it, or of the efficiency and the traffic capacity of the transport elements.

H. — *Preparation of pay sheets.*

Another important application, already in use for a considerable time, is the mechanical preparation of the pay sheets by means of electric adding and subtracting printing machines with which it is possible to get out simultaneously and in full the original sheets and several copies by automatically tallying the vertical and horizontal totals.

Already pay sheets relating to about 30 500 employees are drawn up by this system, which fully responds to expectations and requirements. In fact, in comparison with the old manual system, the following figures can be given : for the establishment of the pay sheets, one clerk was required for every 250 employees; with the new method one per 500 is needed. Each machine covers more than 1 000 employees.

The programme provides for the extension of the system to the pay bills of the 150 000 employees of the railway. The economy in staff can be estimated at 50 %; the economy in the total expenses taking into account the amortisation of the machines, their upkeep and the greater amount of paper used, reaches 40 %.

The completion of this programme will make it possible to obtain an appreciable financial benefit over and above the gradually increasing one of having a more succinct and precise statement of the information with less possibility of error.

III. — Staff.

The very diverse questions concerning the staff can be conveniently grouped as follows :

A. — *Training of the staff,* understood as a means of assuring that the company shall recruit employees capable of properly carrying out the tasks confided to them and also of improving and perfecting the qualitites and output of the human factor;

B. — *Utilisation of the staff,* understood as the distribution of work and the systematic verification of the quality and quantity of work done in comparison with that laid down;

C. — *Institution of premiums* as far as possible to the individual and paid quickly, as well as various allowances in order to take into account particular difficulties.

A. — *Training of the staff.*

The training of the staff includes : selection at the moment of recruiting and during the career of the employee; instruction and training, both preliminary and during service.

As far as the selection of the staff is concerned it has been noted that certain companies make applicants for employment of all categories undergo an examination, while others content themselves with examining certain particular categories.

Furthermore, certain companies admit candidates after seeing their certificates while others make them pass an examination as well.

In like manner while certain companies require candidates for all categories to undergo a medical examination, others limit such an examination to those candidates whose duties will be in connection with the train working and the safety of operation.

Certain companies state that they have adopted psycho-technical examinations.

Nearly all companies make it a rule that all candidates shall undergo a trial which varies in length from six months to a year before being entered on the books. In some cases no wages are paid during this period; in other cases it is followed by a further probationary period.

The staff whose work brings them into connection with the train working is periodically examined on nearly all railways.

In the case of the Italian State Railways candidates are only accepted after a public examination open to non-railway candidates has been passed.

These examinations are based on special programmes brought to the notice of the public and on oral and written examinations on general subjects relating to matters appropriate to the special line selected by the candidate; the subjects and forms are fixed each time by the Ministry of Communications after the constitution, aptitude and physical qualities needed for the work the candidate may have to do have been closely determined, and by retaining the principle of a trial period during which it is possible to be satisfied practically as to his ability.

Without giving all the regulations relating to the recruitment and promotion of the staff, we think it will be enough to describe briefly those concerning the train staff and workmen, classes for which particular care on the part of the railway companies is needed.

Firemen are admitted from among those candidates who have regularly followed an instruction course given at the principal depots on the system and have obtained a satisfactory certificate; this course is open to all would-be apprentice workmen who have got elementary school certificates and have succeeded in the special oral and written examinations on general knowledge and in the practical tests in getting their names on the list of order of merit high up enough to obtain one of the vacant places. They are called probationers for a period of one year after which they are admitted to the staff on condition that they pass a final examination.

The admission of workmen, helpers and labourers is also done by selecting outside candidates who offer the greatest possibilities of succeeding, judging by the results of the practical test, the oral examination on general knowledge, their certificates, and references; they are employed as auxiliary staff for at least two years and during this period their work is carefully watched so that those who are not entirely satisfactory in spite of the care with which they were selected, can be discharged.

For the higher grade staff of the same categories outside candidates are hardly ever selected but such staff is recruited by promotion from lower grades, which is the normal course of promotion of employees who have qualified by passing a first examination and who have to submit to tests and examinations in the service, based on programmes published by the railway.

So, for example, depot foremen are selected from among the drivers who have been tested for some time as relief foremen and who have passed within the number of posts open to competition in their written, oral and drawing examination based on programmes intended to reveal their general knowledge, technical knowledge, as well as their knowledge of their duties.

Technical assistants are recruited from among the first-class workmen and the inspectors who have shown themselves to possess the character and aptitude needed and who have given proof of their general knowledge and specific knowledge of their profession in written, oral and drawing examinations.

The recruiting of drivers from among

the firemen and assistant drivers of some seniority is subject to general tests of a general character, which prove their capacity from the point of view of general knowledge as well as their specific knowledge of locomotives, and the rules and regulations of the service.

First-class and ordinary workmen are recruited respectively from among those workmen and labourers who have proved their professional capacity and obtained a place in the aptitude classification within the limits of the competition. In all cases they are only admitted to the higher grade after at least six months trial in the permanent duties of the grade of employment considered.

These regulations concerning the admission to each grade show in themselves how important professional training is for employees of the above-mentioned categories since it has not only to assure the development in general knowledge, the education and character of the employees, developments closely bound up with the improved operation of the railway, but it also has to prepare staff for specialised duties which cannot be recruited from outside the railway, and it has to form and select those among them who deserve to occupy the managing and supervisory posts.

The following measures tend towards securing this end :

— Internal courses of instruction for apprentice workmen, firemen, and assistants for electric traction — and instruction books;

— Internal courses for drivers and the specialist staff in connection with electric traction;

— Internal courses of professional instruction for depot foremen and technical assistants with a view to preparing them for the promotion examinations;

— Admission of management staff (depot foremen and technical foremen) to external professional improvement schools;

— Apprenticeship of workmen (proposed);

— Publication of technical instructions for the use of the managing and supervisory staff;

— Monthly publication of a « Technical Bulletin ».

B. — *Utilisation of the staff.*

As far as the duration of work and working conditions most suited to achieve a rational utilisation of the staff are concerned, the answers we received limited themselves to indicating the existence of regulations particularly dealing with labour or of special agreements with the different workmen's associations.

In the determination of the principles according to which the regulations for the utilisation of staff of different categories are drawn up, the Italian State Railways have never lost sight of the limits fixed by the Washington International Agreement in 1919.

For some categories and more precisely for those whose duties are most closely bound up with the safety and regularity of the working, with the object of obtaining a better utilisation of the staff and at the same time avoiding any possibility of physical and mental strain, the principle has been adopted of dividing the work required of the staff into :

1. simple attendance;
2. attendance with continuous work;
3. attendance with work broken by rest periods.

In their turn, the periods of duty are fixed according to the nature of the work.

Once the periods of duty have been fixed, another problem of equal importance arises, the evaluation of the quality and quantity of work carried out by each employee and the determination of the requirements. In this connection, the control system most generally used and adopted in the majority of cases consists of supervision by immediate superiors and control by headquarters.

Some companies also make use of certain weekly graphs which show the individual production.

The Italian State Railways, for example, supervise the utilisation of the enginemen by means of the special control system which we have dealt with above.

This systematic control and the institution of premiums with the object of stimulating individual output of which we shall speak further on (see page 1239) have made it possible to obtain the noteworthy results summed up in the graph (fig. 1) which brings out the progressive increase in the work done by the enginemen.

The control of the output and the determination of the needs of the service is, without doubt, facilitated in all those cases in which payment is fixed on the basis of economy in time or by piecework rates.

However, and this is of capital importance, the quality of the work done has still to be controlled.

With this object, the Italian State Railways in the case of certain organisms, as a method of determining the requirements and as a control system, make use of the method of comparing at intervals each shop against itself : in the case of locomotives, reference is made essentially, as unit of production, to the distance and to the virtual ton-kilometres per full train worked (for the determination of the virtual ton-kilometres see page 1236) ; in the case of other stock the route and the average load are the bases of comparison.

Furthermore particular limits are fixed : for example, hours of running repairs for each 1 000 virtual hecto-ton-kilometres; fuel consumption per virtual hecto-ton-kilometre; consumption of lubricants, etc.

In order to adapt the numerical importance of the staff to the variations in the general density of traffic, recourse is had to :

— the engagement of temporary staff;

— the transfer of staff to busy localities from places where there is little work;

— the reduction or even suppression of holidays during rush periods.

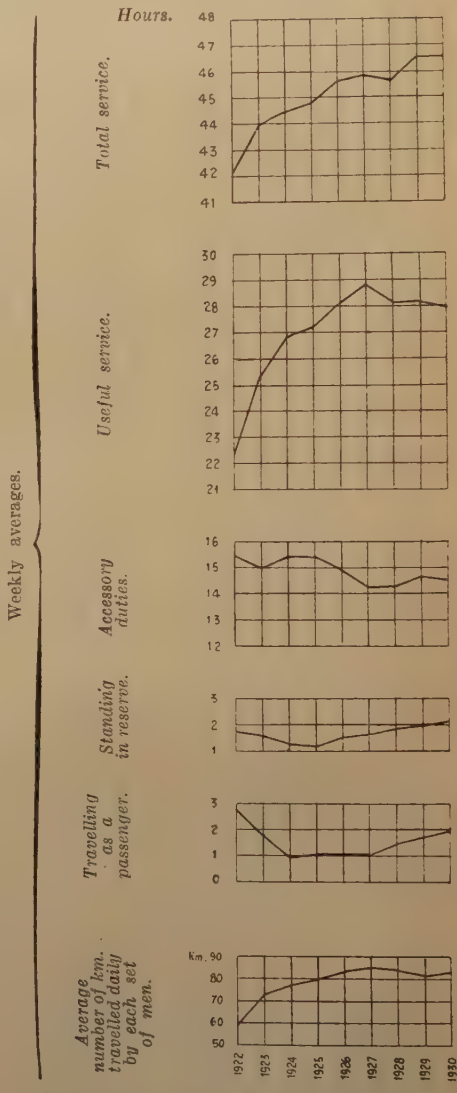


Fig. 1. — Work of the enginemen.

The first of these measures is based on the assumption that the necessary labour is available which is not always

the case, especially when the peaks in railway traffic coincide with an increase in other outside activities in the region in question.

The second measure results in expenses which are often considerable when as is often the case it is a question of moving a large body of staff; usually the staff dislikes it and in consequence, at first at any rate, works less well than normally.

Reduction or suspension of holidays is not always sufficient, and furthermore is disliked by the staff, especially at certain periods, for example, yearly festivities, holiday seasons, etc.

The Italian State Railways, in those cases when an increase in traffic can be more or less foreseen, provide for it by contracting over as they do in the case of the seasonal rushes.

C. — *Premiums.*

The question of giving the staff premiums so as to interest them directly in economies in working expenses, either by increasing their output, or economising materials, is closely bound up with one of very great importance : namely the scientific organisation of work over the vast field of activity of the whole undertaking.

From the replies received from foreign Railway Companies on this point it has not been possible to signal any particullarly interesting case of novelty of idea or of application. We will limit ourselves with reporting in detail what the Italian Railways have done in this matter.

This Railway Administration, in order to solve the problem, has adopted rational lines of organisation, taking care that these shall form the foundation of a whole system : on the one hand they wished to increase the fixed part of the wages by a perceptible percentage thereof, and on the other they desired to assure to the working the benefit of a high output and all possible economy of materials.

The figures given below which show the expenses of the Italian State Railways as regards their staff throw into relief the importance this Administration attaches to the giving of premiums to their staff.

The total expense borne by the Administration as regards its staff amounts in round figures to 2 300 million lire (year 1930).

This figure includes the following sums (*in millions of lire*):

Salaries, wages, and fixed supplements		1 315
Family allowances		230
Premiums :		
to train staff	65	
to locomotive staff	80	
showing greater interest in the service or for increased output	110	
	255	
Miscellaneous allowances :		
For work done away from place of residence, malaria indemnities, indemnities for removals, residence, overtime, various gratuities and grants	100	
		355
Pensions and relief		400
		2 300

In comparison with the totals for the fixed pay, the premiums and indemnities represent therefore (excluding the family allowances) about 27 %.

The expenditure carried by the pensions and relief funds represents 18 % of the total cost of the staff.

These charges relate to a total of 150 000 employees, of which 4 000 are temporary. The percentage of temporary employees which, before the war, was about 25 % has now been reduced to

a bare 3.5 % as a result of various measures, among others the application of arrangements for finding work for old soldiers, and the elimination of staff rendered unnecessary by the new organisation of services and the recent restriction of traffic.

At present, however, there is a tendency to limit the permanent staff by increasing the percentage of temporary hands, who moreover are now allowed to benefit by the measures taken by the Italian Government in favour of the workers as regards social insurance schemes.

As far as the granting of premiums (which, as we have said, are in direct relation with the principles on which the railway system is organised) is concerned, they can be subdivided into three categories :

1. Premiums intended to interest the staff in saving time;

2. Premiums intended to interest the staff in saving materials;

3. Premiums intended to interest the staff in individual output.

To these must be added premiums for particularly difficult work, and other different indemnities which we will deal with later on.

1. *Premiums based on the time saved.*

Premiums based on savings of time are determined by the Rowan formula :

$$P = \frac{T-t}{T} a.p.$$

in which

P = the total premium,
T = the time allowed for the whole,
t = the time taken for the whole,
a = the time taken by each employee,
p = the average hourly rate of pay.

a) *For employees dealing with stores accounts.* — This staff is paid by means of a premium of the Rowan type in accordance with the following principles :

The staff is divided into three classes : copyists, junior clerks, and corresponding clerks, to each of which an average hourly rate of pay is attributed in view of the premium.

As, in applying the Rowan formula, the company gives a maximum bonus which cannot exceed 40 % of the hourly rate of pay, it has drawn up in the case of each type of work the minimum limit which the staff must pass in order to become eligible for the premium and the limit which enables them to qualify for the maximum payment of 40 %.

At the end of the day, each employee fills in a special form on which he indicates the quantity of work produced, a quantity systematically controlled by the head of each section. The premium can vary between 15 and 25 % of the monthly salary.

With the adoption of the production premium, besides an improvement in the quality of the work, it has been found possible to reduce the number of staff employed in this work by about 14 %.

b) *For staff employed in checking rates.* — A type of premium based on time savings is the piecework rate given over and above the interest premium to employees in the department fixing rates applicable to different classes of traffic and obtained from the documents applying thereto.

This is calculated on the basis of the time taken for carrying out the different tasks and rewards the employee for work done by him over and above that included in his normal turn of duty.

Besides this the staff is given : a premium for each debit statement prepared during his ordinary work or piece work, and a share in the debit statements issued on the traffic worked and checked outside normal working hours.

With these last monetary benefits, the

employee is directly interested in the quantity and quality of his output, which, in this case means a real financial gain for the Administration.

c) *For staff employed in connection with the handling of fuel.* — The staff employed in handling fuel, if required to do labouring work, receives 0.70 lira per ton after the first three tons, and 0.80 lira per ton after the first 6 tons. When fuel is handled with the aid of mechanical appliances, payment varies according to the nature of these from 0.05 lira to 0.30 lira per ton.

This premium has automatically reduced to the bare numbers needed the staff employed on this rough work.

d) *For the workmen.* — This premium is received by :

— about 85 % of the workmen employed in the repair shops dealing with locomotives and rolling stock and fixed plant;

— about 50 % of the workmen employed in shops attached to locomotive depots and in breakdown gangs.

This premium will be gradually extended to all the shops of the different depots and breakdown gangs.

75 % of the workmen of the whole railway system are now paid in this way.

The increase of the premium P can at its maximum reach 40 % of the average hourly pay.

If an employee exceeds the time allotted he can be fined.

In the case of badly done work, the workmen can be made to do the work again in his own time, besides being liable to disciplinary action.

In most cases, the time saved, and in consequence the premium are determined for each employee, and each case by means of the formula, $t = a$.

When, on the contrary, several employees are working at the same task for which a single time T is given, the time economy $\frac{(T-t)}{T}$ as a whole is determined and the premium divided up among the employees in proportion to the time a during which each of them worked.

As regards the results obtained, although it is difficult to determine the influence of all the other kinds of measures which have been adopted, it is estimated that the institution of the premium system has given a 10 % increase in output from the workmen concerned.

Organisation of work in the rolling stock repair shops.

The Italian State Railways have made an important use of the premium system, according to the Rowan formula, in the shops, by co-ordinating it with a general rational organisation of the work itself.

We think it interesting to describe this application of the system in all its details.

While, in the depot locomotive shops and the daily maintenance running repair shops, work was done on day work, i. e. on the simple basis of the time on duty, in the locomotive, carriage and wagon heavy repair shops there was at the same time for most jobs a piecework price in addition to the low day rate.

This latter system, which should have stimulated employees to increase their output, gave rise to drawbacks and abuses in addition to the inherent defects in the system itself : that of maintaining without change the cost of labour, of not making employees interested in getting the most out of the material plant and tools, etc., and of making necessary continual revision of the rates with each variation in the cost of living.

Because of this, it was decided to adopt another system in the main repair shops and to extend it subsequently to the other shops which, because of the extent of their equipment, the number of staff employed in them and the difficulty

of the work entrusted to them, form a whole of equal if not of greater importance; this new system was the task system based on the time, according to a simple formula, which the workmen could easily understand, and which eliminates the old defects and inconveniences.

The Rowan system was chosen, and the maximum value of the premium fixed at 40 % of the hourly rate so as to limit the tendency to aim at excessive gains through forced activity or careless work, or the two combined.

The preparatory work necessary to bring about this reform proved to be particularly long and difficult in actual fact.

It was necessary to make in the case of each kind of work a detailed analysis of each of the operations involved, to define the method to be used for each of these operations and the way of doing it, and in connection with these to fix the time to be allowed for doing it.

Such a scheme led to the establishment of a large list of rates; but this apparent complication was largely made up for in practice by the advantages obtained from a certain and objective interpretation which made it possible quickly to make the analysis needed to solve whatever case might present itself, and likewise to claim a closer application and more certain control on the part of those in authority. Furthermore, it became possible, with rates detailed in this way, to determine in most cases the time saved, and consequently the premium due to each employee.

The number of headings and the times allotted in the rates make up as a whole the following figures :

a) about 15 000 for the main repair shops for steam locomotives;

b) about 30 000 for the main repair shops for electric locomotives;

c) about 15 000 for the main repair shops for carriages and wagons;

d) about 60 000 for the locomotive depot repair shops;

e) about 10 000 for the running shed repair shops.

From the beginning it was realised that it would be necessary to make it easy for the managerial staff to apply the rates to the very varied cases which turn up in practice, and to reduce to the minimum all clerical work in connection with work orders; in this way the supervisors were freed as much as possible from these indispensable duties which nevertheless take up much of their time that could more profitably be spent in the more essential duties of supervision. With this end in view diverse measures have been adopted, among which :

the institution of *work sheets* (see Appendix 1) which includes a dimensioned drawing of the part, a list of the materials needed, with the rates and times fixed for the completion of the part;

specialised orders (see Appendix 2) which, for all the more important parts give a statement of the rates and the time fixed for repairing the more frequent kinds of damage, so that the clerk has only to add under each heading the number of units to be repaired and the form is then complete;

repair sheets for extensive periodic repairs on which are specified all the operations to be done on such occasions, dividing it among as many sheets as there are specialist workmen concerned. Thus, as soon as a locomotive arrives at the shops, without more ado, orders are given for it to be stripped down with the general prescription to carry out all the erection work specified on the sheet. As soon as a given set of parts has been taken off and cleaned, an examination is made to determine the repairs needed; only the numbers of the rates to be applied to the parts to be repaired are written down, and the numbers of the

manufacturing sheets for the parts to be replaced. Based on these numbers, the drawing up of work orders is greatly simplified and can be entrusted to a lower grade of technical staff.

The difficulties met with in the gradual application of this reform were no less than those found in drawing up the rates.

The adoption of the new system of payment based on a preliminary allotment of time for each piece of work, even when the time in question was very short, and on the determination in each case of the time employed, in order to guarantee the interests of the Company as well as the staff, requires :

1. an exact and uniform application of the rates;

2. a rigorous verification of the quality of the work;

3. a systematic control to make sure that the work ordered exactly corresponds with the work done;

4. the drawing up and distribution of work orders at convenient times in order to avoid all uncertainty in their execution and to obtain a continuous flow of work in the different sections and productive co-ordination between them.

It was consequently necessary to revise the staffing of the shops in order to avoid on the one hand a lack of supervision, and on the other a lack of assistance for the workman in order to guide and aid him to get the increased output required of him; and it was likewise necessary to perfect the general organisation, especially with regard to the preparation and the co-ordination of work so as to eliminate every cause, that independently of the goodwill and ability of the workman, might result in a change of output by reason of the different conditions under which the work was carried out.

We will pass over all improvements in the technical domain which, while being used today in the name of scientific organisation, may be discarded because superseded by more efficient methods.

On the contrary, we will briefly deal with some measures that have been inspired by definite principles that, at least as far as we can see today, are not likely to be superseded.

In the past, each foreman had to distribute the work and at the same time help his workmen; he decided what repairs were necessary, directly made all arrangements for the execution of the work, the getting together of materials and tools needed to do it; he co-ordinated the activities of his section with those of other sections by personal contact with his colleagues; finally he made sure the work done was checked over and was responsible for the proper utilisation of the staff and equipment of his own section.

Such an accumulation of duties, except in the very particular case of certain small sections, made it very hard for him to do them all thoroughly, which resulted in the quality of the work and the utilisation of the equipment and men being unsatisfactory, as well as in the immobilisation of the stock under repair.

Therefore it was decided to limit the duties of the executive foremen: these were cut down to the supervision and helping of work so that it might be done according to the rules and within the time limits set. Other foremen, independent of the first, were appointed to cover the following duties:

a) examination of parts and arranging for the necessary repairs; get out particulars of materials wanted; distribution of work orders, of stores and special tools to all sections concerned;

b) the co-ordination of the productive activity in the different sections so as to enable the various units to follow their proper cycle of work without impediment so as to arrive at the erecting point in the necessary

chronological order and to feed these sections continuously;

c) control of the carrying out of all the operations ordered.

The shops staff, except for slight modifications made necessary by local needs and the necessary combining of some duties at less important places, is shown on the diagrams (figs. 2 and 3):

Organisation of the depots shops,
Organisation of the heavy repair shops,
Organisation of the running shed repair shops.

The *preparatory work* which, for the reasons already given, is of particular importance, is achieved by means of:

a) the establishment of a programme of repairs to be made so as to feed uniformly all the sections;

b) before the work orders are issued examining the parts to be repaired so as to establish first of all what repairs are necessary, what materials and special tools are needed, and also the shunting to be done so as to get the locomotive to the place required in order to avoid all uncertainties and all loss of time in carrying out the work eventually ordered. Figures 2 and 3 show the plan of organisation now in force on the Italian Railways.

The programme given in paragraph *a*) is used for repairs of an average or certain importance, as it is impossible to prepare one for less extensive repairs; the inspections with which paragraph *b*) is concerned on the contrary apply in the case of all repairs. If a simple examination of the damaged part still in use does not suffice, the work order then deals simply with stripping it down; the order is completed after-

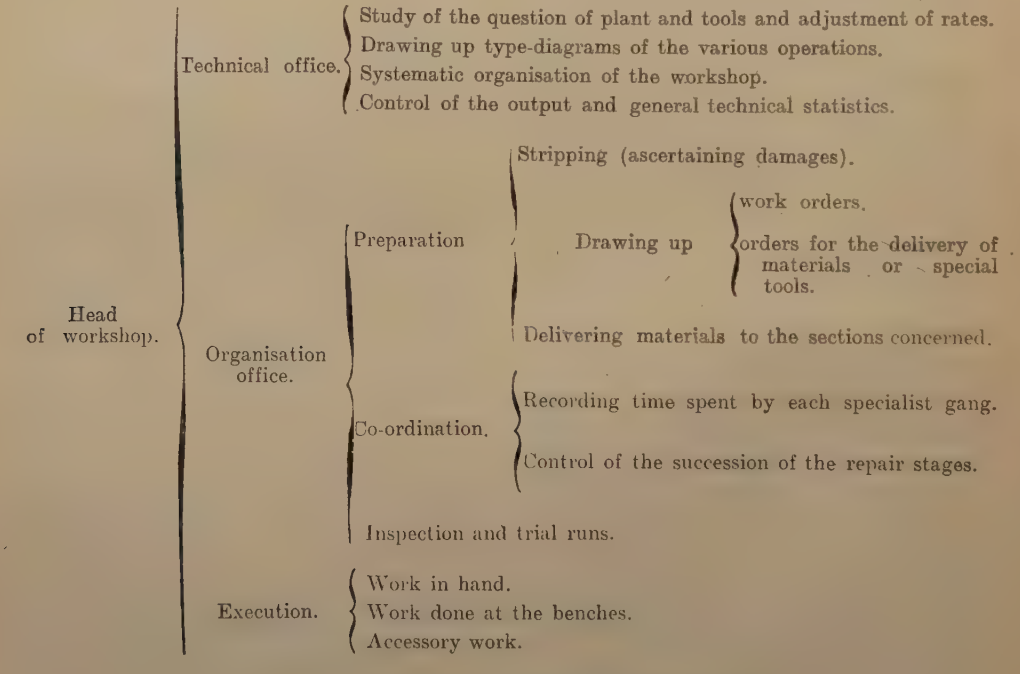
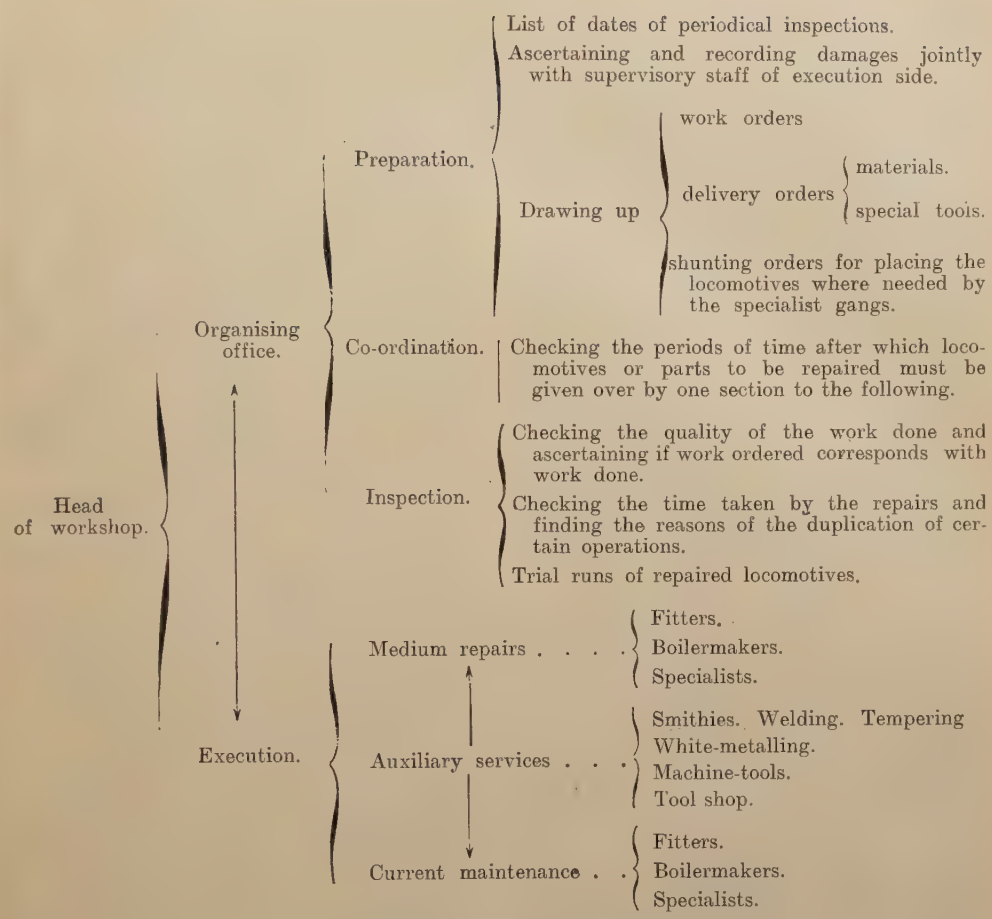
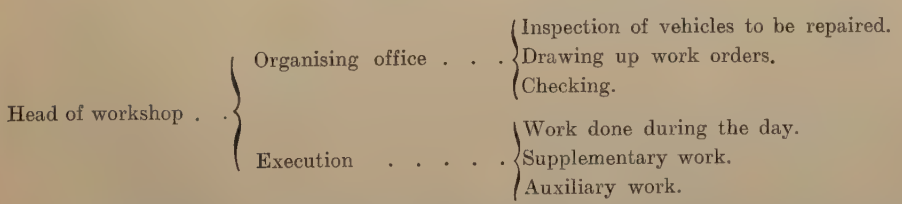


Fig. 2. — **Organisation of the main repair shops.**



Organisation of depot repair shops.



Organisation of the depot workshops for current maintenance of rolling stock.

Fig. 3.

wards when a further examination makes it possible to say exactly what repairs are needed. However, in particular for average repairs, these preparatory operations take place on the occasion of an inspection of the locomotive

some time before it is taken out of service, by taking into account the condition of the engine after considering the mileage covered since its last heavy or average repair, the dates of inspections and prescribed examinations, the actual dimensions of its fittings or important parts in comparison with the minima laid down, etc. This preliminary examination is completed by another made during or after the locomotive, now in the shops, is stripped down.

As far as current maintenance is concerned, employees who prepare the work have a timetable enabling them to get directly and verbally from the drivers all information required to ascertain the damage, to examine the locomotive, even if it arrives at the depot during the night, and to prepare work orders before the shop opens.

The *checking and control* intended to assure that work shall be done thoroughly and correspond exactly with what was ordered, have no special features about them except the following principles:

Work that is found to be badly done must be made good by the same workmen without any further time allowance and consequently at their own loss. It is the same for current maintenance repairs to locomotives which have undergone an average repair: as long as the locomotive has not covered a certain mileage any repairs are made by the same men who did the work without any time being allowed which would imply a premium.

In order to interest the enginemen in pointing out badly done work or work not done at all and thus leading them to take part in supervising the work done, each depot draws up at the end of the month a list of such employees in order of merit taking as a basis the hours of current maintenance repairs required for the locomotives in their charge; this list also serves to estimate the keenness shown by the enginemen in looking after their locomotives. Furthermore an enquiry is now being made into the possibility of giving the enginemen a special premium in connection with fuel economy in order to make them as interested as the Company in keeping down expenses.

The *co-ordination* is intended to regulate the productive activity of each section of the shops so that the different kinds of work shall be carried out at suitable times and that each part shall follow its own working cycle and be delivered at the right moment where it is needed for the repairs to be carried out in a continuous fashion, without delay, by reducing to a minimum the time the locomotive remains in the shops.

For this the repair type-diagrams (Appendix 3) are very useful: from the date the locomotive goes into the shops for repairs these diagrams fix the dates by which the more important operations shall be finished, the dates the different groups of parts after repair shall be returned, and finally the date for erection.

Furthermore, in the lower part of the diagram, the dates on which the work given to the organisation office and the work assigned to each specialised production unit were finished are given. Special extracts from these diagrams, either numerical or graphical, pinned up in various parts of the shops, show the foremen and workmen what is the cycle fixed for each operation. An official from the organisation office checks every day the amount of work done to make sure that the programme is being followed out; he draws the attention of the foremen and workmen concerned to anything that threatens to prolong the work beyond the fixed limits and gives a daily report to the head of the shop of the results of his inspection and the state of completion of the work in hand.

In certain shops periodic meetings of the foremen are held from both the organising and working sections under the chairmanship of the head of the shop.

The general progress of the work is examined and any modifications that should be made in the programme are decided upon.

Some of these diagrams (see Appendix 4) over and above the information we have spoken about, also show the tracks on which the different operations are to be carried out.

In the past, the frame of the locomotive with its various parts still in place (cylinders, supports, etc.) and the body of the vehicles, once the wheels had been removed, were put in some particular place where all the necessary repairs were carried out. The same thing took place in the case of the locomotive boilers when lifted off the frames.

The result was that all repairs were in the hands of a single gang of workmen, or that different groups of specialising workmen went from one frame or boiler or body to another in order to do their particular work.

Further inconveniences arising from this system where the necessity of multiplying the sets of particular tools issued and of much transport not always justified.

A study was made of the subdivision of the complete cycle of repairs into a certain number of stages or phases (see Appendix 5) for each of which, or at least for definite groups of phases according to the topographical needs of each shops, a definite standing position was arranged so that it became possible to avoid moving the men from their place of work and in many cases, economically to adopt improved tools which, thanks to the new system, were only required in limited quantities.

In such cases as local conditions allow, that method is adopted in which the different parts are re-erected on the locomotive or carriage where they were taken off and in this way the amount of transport is greatly diminished.

Simultaneously with the creation of places at which specialised work was concentrated, the specialisation of the staff of workmen was progressively developed in order to increase the output and improve the quality of the work.

For example, in the shops in which repairs to electric locomotives are carried out, there are 48 special operations, a figure which does not include machine-tool work, forge work, welding, etc.

In order to accelerate as much as possible the productive cycle and to reduce to a minimum the immobilisation of stock needing repair, a limited co-ordination of the shops, was not enough.

Consequently, an attempt was made to have each shop specialising in the repairs of certain groups of rolling stock, a particular effort being made to get over the special difficulties arising from the lay-out of the railway system, and especially in the case of locomotives, from the existence of several groups (part of which came from the old railway companies, part from war captures), distributed over the whole system.

To avoid repair costs being burdened by heavy transport expenses, locomotives and carriages have to work to the shop to which they are going for repair.

In the case of *bogie carriages*, each shop repairs certain *specified* carriages; it is able therefore to control the proper carrying out of the repairs and to fix in good time the extent of those to be carried out periodically, and prepare in advance the repair programme and indents for stores.

In the case of the locomotive shops, while in the past the rule was that each depot was to assure current maintenance repairs and medium repairs to its own units, gradually all medium repairs have come to be concentrated in one shop by limiting the others to ordinary running repairs alone.

When the first fruits of the new organisation began to be apparent, especially as far as the improved quality and the

greater durability of repairs effected were concerned, gradually the revision of repair standards was taken in hand, especially with the object of enabling the Administration to formulate, even some time in advance, repair programmes and the amount of labour and material likely to be needed, so as to obtain a minimum difference between the real needs and those estimated.

In the case of the Italian Railways, the periods at which certain repairs known as « organic repairs » have to be made were fixed in order to distinguish these from the small occasional repairs regularly carried out from day to day in the intervals of service.

The result was that locomotives came in for repairs at fixed intervals, after having been in service for a period that naturally varied with the kind of locomotive; the result of this was that while it was possible to foresee with sufficient exactness the number of units to be repaired, the volume of the repairs to be made was on the contrary very variable, and often, in order not to stop the locomotive again soon after it went into service, repairs were made which were not absolutely necessary at that particular moment.

For this reason, it was decided to keep this periodical system only in the case of examinations made to see how certain parts were behaving, and to make the base for organic repairs the work done by each unit, so that these came in for repairs with a known degree of wear.

As far as carriages were concerned, the question of collecting together information on their utilisation and mileage had already been studied: on this basis, it is thought that it will be possible to replace the actual periodic repairs by fixed types of specified repairs, as in the case of locomotives, according to the work done by each unit.

The problem of repairs to stock is not solved solely by taking measures to improve the output of the staff and equipment; likewise the problem of reducing to a minimum the immobilisation of stock under repair is not exhausted by specialising the installations over the railway system and coordinating the work done within the limits of each shop.

When all abuses are got rid of and the service is working with a satisfactory degree of regularity, the time saving realised by the staff is certainly proof positive of its output. All the same it cannot be concluded from this that the action of the supervising staff and the output of the equipment have been equally satisfactory. In order to know this it is necessary to be able to estimate if the cost of stores, the immobilisation of the stock and the total volume of repairs have been kept within the closest possible limits.

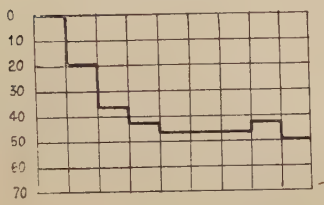
Practically, a preliminary technical analysis of repair work which a priori fixes such limits is not possible, so that all that can be done is to obtain elements of comparison by comparing the results got in the different installations (when conditions are comparable) and the results of each installation as well as those of the whole railway with themselves at different times.

For that it was necessary to lay down the basis for an analytical accountancy which determined relatively to the unit of work done for the stock the costs of labour, of materials and of the indirect charges, separately for each unit of rolling stock, for the parts of each unit and for the kind of repair.

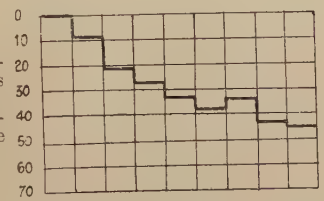
These were used not only in the investigation of ultimate improvements in the parts and the various apparatus of the stock but as regards their utilisation in the various services; they also contribute, as far as experience as a whole allows, to a more exact evaluation of the requirements as regards repairs and to the determination of various particular limits, for example the hours for

Percentages of the reduction of staff and accidents to trains as compared with the working year 1921-1922.

les (current maintece and main repair ps).
1 000 000 axle-kilometres.

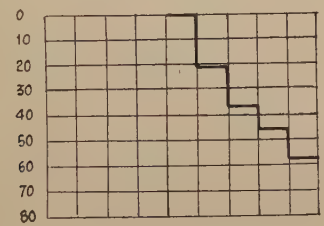


locomotives and elec- locomotives (Depots main repair shops).
1 000 000 virtual hecto--kilometres of complete in.



Compared with the working year 1925-1926.

Steam traction.



Electric traction.

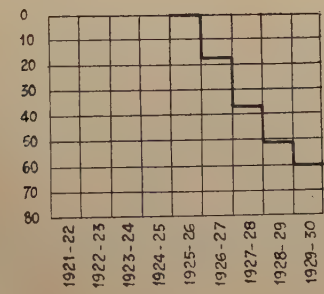


Fig. 4.

ordinary running repairs, per 1 000 hecto-ton-kilometres, the hours of work for a given type of repairs; the consumption of certain materials, etc.

In order to give a general view of the results obtained in regard to the output of the workmen and the quality of the work of the shop as a whole we indicate in figure 4 the percentages of the reduction of staff and of the accidents to trains. For the improvement in the consumption of fuel figure 5 should be examined.

Fuel consumption per virtual hecto-ton-kilometre, of complete train, hauled.

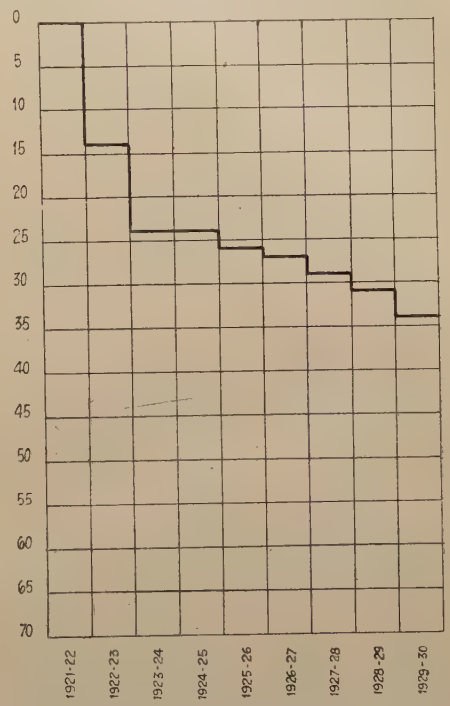


Fig. 5. — Reduction per cent as compared with the working year 1921-1922.

2. — *Premiums based upon the saving of materials.*

a) *Fuel.* — The most important of the *premiums intended to interest the saff in saving materials are those relating to the consumption of fuel.*

1) — The premium for fuel economy

is calculated for each locomotive quarterly by means of the formula.

$$P = \frac{C}{A} (A\text{-}C)\, p$$

in which

P = the total of the premium;
C = the quantity of fuel consumed;
A = the quantity of fuel allowed;
(A-C) = E = the quantity of fuel saved;
p = 25 % of the average price of fuel during the quarter.

The amount of the premium in terms of the independent variable E = (A-C), is represented analytically by a symmetrical parabola relatively to the straight line of the equation $e = \frac{a}{2}$ (axis of the parabola) which cuts the axis of the e's at the points of abscissa $e = O$, $e = a$; for these values the premium is equal to O, and has a maximum when $e = \frac{a}{2}$.

The premium per ton of fuel saved increases so long as the saving does not exceed half the quantity allowed; when the saving exceeds one half, the unit price falls.

These characteristics of the curve being given it has been laid down that the formula is only applied so long as the unit consumption remains higher or is equal to half the quantities allowed. And for the reason that while the determination of these quantities cannot be very exact, it is not practically possible without error or abuse for the consumption to be less than half the amount allotted.

The quantity A is established each quarter, by group of locomotives or by installation, on the basis of the hectotons per virtual kilometre of full train hauled, as well as of the minutes lost or made up by the train engines and on the basis of the shunting hours in the case of shunting locomotives.

Calculation of the virtual length of the lines and of the virtual hecto-ton-kilometres.

The virtual lengths L_v for steam traction are taken from the tables published by the State Railways in 1908 and kept up to date by technical checks carried out in a uniform manner; they are calculated from the point of view of the tractive work done and of the consumption of water and coal by the steam locomotives.

The basis taken is an *average* tractive resistance of 4.5 kgr. per tonne on a straight level line. This coefficient is increased to 5 kgr. in order to take into account the consumption of fuel when running independent of any work done by the locomotive (consumption due to the loss of heat through the boiler walls, to leaks, to special equipment, etc.). The minimum virtual length when running down grade would be one-tenth of the real length; it has been raised to 1/5 in order to take into account the consumption when starting and through braking.

In order to take starting into account, the minimum limit of 1 virtual kilometre has been observed for each run from a station to the next one.

Consequently, ignoring curves, the virtual length has been established on the basis of 1 km. over the real figure for every 5 metres rise; and of 1 kilometre less for every 5 metres drop with a minimum of 1 virtual kilometre every 5 real kilometres and of 1 virtual kilometre for each journey between two stations.

The virtual lengths have been established on the basis of the following formulæ :

$$L_v = L_r + \frac{h + pl}{5} \qquad (1)$$

$$L_v = \frac{1}{5} L_r \qquad (2)$$

in which

L_r = the real distance in kilometres;
h = difference in level in metres, positive or negative, according as it is a question of rising or falling gradient;
p = the slope per thousand equal to the curve;
l = length of the curve;
L_v = virtual length in kilometres.

Formula (1) is used for runs on rising gradients or on the level and for those on falling gradients of less than 1 in 250; formula (2) is used for runs when the down gradient equals or is steeper than 1 in 250.

In principle, when applying these formulæ the run to which one or the other applies should be considered separately; exception should be made of very short runs in consequence of the use, if the case arises, of the available momentum.

This method for calculating the virtual lengths in connection with the consumption of fuel for steam traction has so far on our system not led to an equivalent method for application to the electrified lines.

The work of the locomotive at the drawbar expressed in virtual ton-kilometres hauled is given by the product P. Lv in which

P = the weight of the train;
Lv = the virtual length of the section considered.

The total work done in virtual ton-kilometres of the whole train, *i. e.* inclusive of the weight of the locomotive and of the tender, is calculated from the formula:

$$L = P.L_v + (30 + 0.7\,M')\,L_r + (M' + M'')\,L_v$$

in which M′ and M″ are respectively the average weight in service of the locomotive and of the tender.

In this formula, the first term between brackets represents the work required to overcome the resistance of the mechanisms and that of the air at the front, whereas the second term represents the work required to overcome the tractive resistance of the engine and of the tender considered as vehicles.

To simplify the calculation and to increase the value of the work done on mountain lines where, in view of the greater cut-off usually required, the efficiency of the engine is slightly less (a circumstance which it is only just to take into account) the work of the locomotives is calculated for the allocation of the economy premium, from the fol lowing formula:

$$L = P.L_v + (30 + 1.7\,M' + M'')\,L_v$$

in which all resistances are adjusted to the virtual length although the additional resistances of the locomotive are proportional to the real length, not to the virtual.

The premium is paid quarterly, not only to simplify the accountancy work, but also because the base period being longer, an automatic compensation for the inevitable errors in calculating the quantities allotted and in the different services worked by each locomotive are more readily obtained.

The quarters have been selected so as to have atmospheric conditions more or less equal in the months included in them :

March, April, May;
June, July, August;
September, October, November;
December, January, February.

In order to take into account the greater quantity of coal required for the increase of speed necessitated to make up for delays, the total quantity for each locomotive in steam, working a train, as obtained from the virtual hecto-ton-kilometres multiplied by the unit quantity, is increased as follows:

— 15 kgr. (33 lb.) for fast and express trains,

— 10 kgr (22 lb.) for accelerated trains, stopping trains, mixed trains and the like,
— 5 kgr. (11 lb.) for goods trains,

for each minute recovered in working the train (except those recovered on down gradients indicated on a special table or with trains with more than two locomotives at the head). Corresponding reductions on the total quantity are calculated in the case of unjustified delays and for which the staff is responsible, in order to take into account the abnormal saving which results from these delays.

The various quantities of fuel are estimated in comparison with coal from the following coefficients:

Large coal as mined	1
Briquettes	1
Coke	1
Lignite	0.25
Char	0.50
Wood	0.50

In the case of multiple traction, the weight hauled is distributed between the locomotives in service in the train for the distance worked in proportion to their motors and coupled wheels respectively.

b) *Lubricants and lighting materials.* — Other premiums are granted to the locomotive staff for saving of consumable stores. These are:

α) Premium for lubricants saved calculated for each locomotive and quarterly according to the formula :

$$P = (A - C) \times 0.60$$

in which

A = the quantity of lubricant allotted, in kilogrammes. As a general rule each group of locomotives and each installation receives a winter allocation and a summer allocation for each real kilometre run.

C = the consumption in kilogrammes. For this, the various lubricants are brought to a common scale by means of certain given coefficients.

β) The premium for lighting materials saving, calculated also for each locomotive and quarterly by means of the formula :

$$P = (A - C) \times 0.60$$

in which

A = the allocation in kilogrammes of the lighting materials per lighting hour of the lamps. For obvious reasons the allocation is the same for all types of locomotives.

P = the consumption in kilogrammes; the various lighting materials have been brought to a common scale by means of certain given coefficients.

The men who share in premiums for saving of fuel, lubricants and lighting material are :

— the enginemen.

For each locomotive which, during the quarter in question, has effected a saving, the fuel premium is added to the lubricant premium and the total is distributed between the men who during the quarter have worked the locomotive in proportion to the real distance travelled by each of them and in the proportion of 3/5 to the driver and 2/5 to the fireman or helper.

As regards the fireman working on the locomotives with large fireboxes and used on runs which cause exceptional fatigue, the normal premium is increased by a supplement equal to half the premium itself.

As a matter of justice, in order that the value of the premium should not be affected by circumstances outside the control of the men, and to give equilibrium between the amount earned by all grades, it became necessary to lay

down a maximum limit per man for the premium which is fixed in ratio to each 100 kilometres actually worked by the staff and with the nature of the work done.

— The management staff of the locomotive depots receive in proportion to the days at work a sum equal to 3 % of the total economy effected by the enginemen of the establishment to which they belong.

— The supervisory staff and, in certain limits those which do not work under the premium based on a saving of time being attached to the repairs and the maintenance of locomotives, receive in proportion to the hours they are at work a sum equal to 1 % of the total economy of material effected by the enginemen of the depot at which they work.

— The supervisory staff in the offices responsible for supervising the consumption of material and for controlling the use made of the traction units receive in proportion to the days at work a sum equal to 1 % of the material saved.

The institution of premiums based on the saving of materials has had happy results : by comparing the consumption of the last years with that of the year 1921-1922, it will be seen that it has been possible to bring the figures back almost to the pre-war level.

3. — *Premiums intended to increase individual output.*

The premiums which have the object of interesting the staff in increasing their individual output are on the Italian Railways :

a) General interest premium. — This is granted to all the office staff and to the executive staff which does not share in any other premium, that is to say to more than 100 000 employees.

Distributed by the number of days at work (excluding consequently days of absence for no matter what cause except those resulting from changing the turn of duty), it has a minimum and a maximum for each grade and can be raised one or more degrees under the following conditions :

— exceptional importance of the post and the responsibilities attached thereto;
— special missions confided to the man in addition to his normal duties;
— particular difficulties under which the work is done.

The premium can be reduced or suppressed for irregularity in carrying out work, or for other reasons such as negligence or small output.

The principal feature of this premium is to directly interest the staff to reduce the number of days lost by stimulating them to regular working.

Particular regulations as regards the application enable it to be possible to differentiate between each class the rate of the premium and to proportion it to the importance and specialised nature of the employment, to the difficulties of the various duties fulfilled by the men of the same class, and also to put it into relation, by reducing it or suppressing it during one or more days, with the irregularity or bad service of a man.

The executive staff covering management duties, the supervisory staff in the locomotive depots and the workmen, when they do not work under the premium for better output, and the labourers can also receive, in order to reward them for exceptional individual output or for an economy realised in the use of materials and of labour, a quarterly supplement of the interest premium. The supplement cannot exceed 4/10 of the premium received during the quarter. The total number of tenths of the premium distributed cannot exceed :

1. three times the number of the men able to obtain it as regards the management staff of the depot, the technical staff and the workmen as well as the helpers;

2. the number of men in the remainder of the staff.

The results of the interest premium have been satisfactory although it is not possible to calculate with exactitude in all its elements the work done by each employee. It is not possible to translate into figures the advantages resulting from these premiums as the improvement in production which resulted was also due to other factors such as the better and more scientific organisation, the better sense of discipline and of the love of work which the present regime has been able to inspire into them; however, it is possible to find an indication in the reduction in the number of absences for all causes (except the weekly rest and the holidays) from about 15 % in 1920-1921 to 10 % in 1930.

b) *Premium per working hour.* — This is granted to the locomotive staff and to the men on the trains (about 30 000 men).

The staff driving locomotives or rail motor cars whether steam or electric receive a premium for each hour on duty of 1.60 lire in the case of a driver and 1.20 lire in the case of a fireman or the assistant on electric trains for the first 100 hours of work in the month and of 2.40 lire and 1.80 lire respectively for the hours each month exceeding the 100 first. It is granted after taking into account the various operations before departure and after arrival, of work done away from home as well as delays on arrival exceeding 30 minutes and is paid :

— without reduction for each hour employed according to the timetable of the trains, when driving the locomotive;

— 2/3 in local services;

— 1/2 for work at home stations and for work at the depot inherent to the work of the engine;

— 1/4 for journeys ordered outside duty and for standing in reserve and available at the depot.

The men travelling with the trains receive an allowance for each hour of work, according to grade, varying from a minimum of 1.10 lire to a maximum of 1.60 lire. It is increased by 50 % for the monthly hours of work exceeding the first 100; it is distributed after taking into account the various operations before departure and after arrival and of delays on arrival exceeding 30 minutes.

It is paid :

— as a whole for each hour worked according to the timetable when travelling with the trains;

— 2/3 in local services;

— 1/2 for time employed at home station for handling of wagons and goods, for office work and other work;

— 1/4 for journeys out of duty hours and for periods when simply being in reserve at the depot.

c) *Mileage premium.* — This is paid for each 100 virtual kilometres calculated according to the method indicated above, run when with the train at the rate of 2.10 lire to the driver and of 1.40 lire to the fireman or to the assistant on electric trains.

The electric traction staff can, in certain particular cases, receive this premium at a higher rate up to a maximum of 4.20 lire for the driver and 2.80 lire to the assistant for each 100 virtual kilometres.

The premiums per hour of work and the premium for distance run has a marked influence on the utilisation of the locomotive staff and the train staff.

Immediately after the war the hurried extension of the 8-hour day to this class of labour had prevented the work being rigourously controlled.

The staff lacked the necessary encouragement to give a good individual output, the average hours of work of each man kept well below the maximum limit of 48 hours fixed by law.

Thanks to Fascism, the discipline of the service has been regulated and the above mentioned rules having been fixed for remunerating the staff according to

the duration of the service and the kind of work, it was very soon possible to improve appreciably the output of the staff, whether the general weekly average of hours of work, or as regards the kind of work, by increasing the percentage of useful work (the effective work done in working the trains) with a corresponding reduction of profitless work (journeys light, reserve duty, etc.).

Figure 1, page 1224, shows the average use of the enginemen in regular work (69 % of the staff) in 1922 and in the present year from the working table. The diagrams show the improvement relatively to 1922 by class of work (*useful*, i. e. on the train; *accessory*, i. e. of preparation before departure and to put the locomotive in order after arrival; *reserve*, *i. e.* waiting to take up duty if need be; travelling as a passenger, *i. e.* not on duty in order to go to work a locomotive in another place or to return to the home station when work has been completed).

The new discipline in the work and the rational and well proportioned remuneration have made it possible to reduce appreciably the staff of enginemen, for equal distances worked by the locomotives.

Figure 6 shows the advantages realised for the same reasons as regards the train staff.

b) *Premiums granted to employees responsible for issuing drafts.* — The employee responsible for issuing drafts in favour of contractors receives special annual allowances according to the saving secured for the company as a result of the discount that the firms grants in order to obtain the payment of their invoices before the term laid down in the contract. The amount of this benefit varies between 2 and 3 % of the total of the profit. The distribution is made according to the grade and the energy displayed by each man and is controlled by his superior officers. In this way the staff has an interest in issuing the drafts more quickly; the management while receiving a profit can assist those firms who need early payment of their account and avoid unjustified preferences in dealing with these payments.

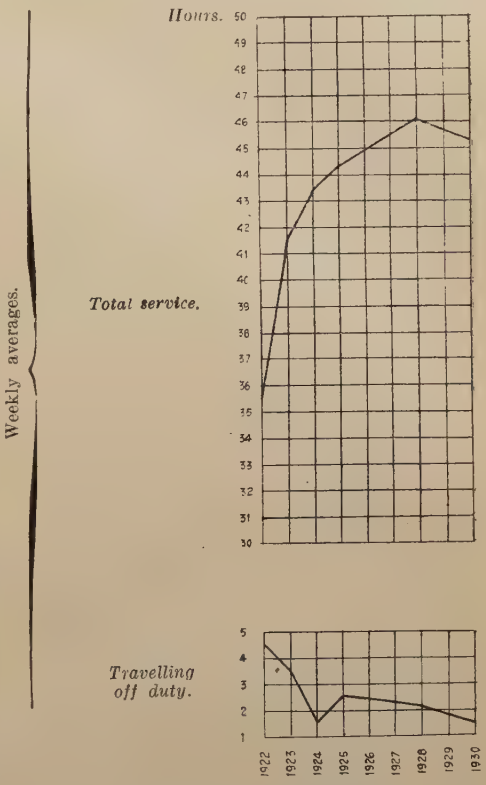


Fig. 6. — Work done by the train staff (guards, brakesmen, etc.).

4. *Premiums for particularly trying work.*

A. — *Overtime.* — Work ordered and carried out outside the normal period of work is considered as extraordinary and gives rise to special payment. This extra work cannot exceed as a rule the period of two hours per day. The hourly premium corresponding to this is fixed at 1/8th of the daily rate increased by 6 % with a maximum of 3 lire.

B. — *Night work.* — Men required to work between 10 p. m. and 5 a. m. receive according to their grade and the nature of the work done an hourly additional rate which varies between 0.4 and 1.4 lire and is only granted to the men entitled to the fixed allocation for full night service.

The men who during the whole or part of this time between 10 p. m. and 5 a. m. (inclusive) remain away from their home station for locomotive purposes receive an allowance of 6 lire for the driver and 5 lire for the fireman and assistant on the electric trains. In order to calculate the total of these allocations, account is taken of the time required for the accessory operations as is done for the hourly premium for work and also of the delays to the train for which the men themselves are not responsible.

The fixed night allocation is paid to the train staff and is settled on the following basis :

First class guard, head guard and leading guard	6 lire
Guard and brakesman	4 lire

The man has no right to this allocation when he receives an allowance for travelling.

c) *Duty away from home station.* — The locomotive men and the train staff who remain away from their home station for a period of time greater then 24 hours are entitled to the travelling allowance.

d) *Duty in malaria-infested regions.* — The men who remain permanently in marshy districts or work frequently in such localities during at least 15 days consecutively are granted special allowances.

These localities are divided into two zones : of serious malaria and slight malaria; the allocation is fixed at 1.80 and 0.60 lire respectively per day and is only paid during the period between the 1st June and 30th November. For men residing in the serious malaria zone the allocation is increased by a supplement of 0.20 lira for each child and for the wife on the condition that they live with him.

A special arrangement regulates the payment of the malaria allocation to the locomotive and train staff obliged to run through marshy districts.

e) *Work in tunnels.* — The locomotive and train staff running on lines with long tunnels and where the service is particularly trying receive a supplement of pay which is in ratio with the length of the tunnel and cannot exceed for each journey the following rate :

0.80 lira for the 1st class drivers, drivers, 1st class head guards, and head guards;
0.65 lira for the principal guards;
0.50 lira for the firemen and guards;
0.40 lira for the brakesmen.

f) *Goods transhipment service.* The men travelling with the trains who during the journey load, unload and put into place goods in the wagons receive a payment according to the established regulations for hourly work premiums on applying the following hourly basis :

0.35 lira for the 1st class head guards and head guards;
0.30 lira for the principal guards;
0.25 lira for the guards;
0.20 lira for the brakesmen.

g) *Working trains without a brake van.* — The first class head guards, head guards and principal guards required to travel with goods trains without brake van and who travel in the covered brake shelter near the locomotive receive a special allowance to be fixed in each case according to the particular difficulties met with on the lines run over; it varies between a minimum of 0.60 lira and a maximum of 2 lire for each journey, the maximum daily amount varying between 2 and 4 lire.

5. *Premiums and various methods intended to stimulate or reward the activity of the staff.*

Payments are made to the men who suggest improvements in the working in the shops, in the plant, etc., these payments being proportional to the importance of the suggestion put forward.

In the case of suggestions being carried out which are protected by patents, the men have the right to work them by third parties with the sole restriction that the railway benefits by the application without cost.

Gratuities which may amount to 500 lire are granted :

— to the men who contribute to avoid irregularities in the running of the trains;

— to those who discover or assist in causing to be discovered thefts of fraudulent deeds in the carriage of goods.

The men responsible for paying salaries and wages to the staff receive a premium of 0.12 lira for each 1 000 lire paid, this being allocated monthly on the basis of the total of the sums paid out during the month provided that this total exceeds 50 000 lire. The premium is reduced by one half in the case of the cashier who acts as paymaster.

In addition allowances are granted for the discovery of irregularities in the preparation of the way bills and in the application of the rates (in addition to the premium for improved output).

The staff, responsible for the control, discovering irregularities or abuses in passenger transport, in that of luggage or of goods, generally receive as a premium 30 % of the total of the sum actually imposed as a supertax according to the rate and the conditions in force for such transport.

The premium is reduced to 10 % in the case of irregularities found in the declaration of the weight of goods dispatched and in no case can it exceed a maximum of 500 lire for each irregularity or abuse.

The staff cannot claim any premium when no surtax has been imposed nor when the administration decides it is desirable to abandon or to repay the penalty imposed; but in this latter case the man who discovered the irregularity or abuse receives, for each breach of the regulations found, an indemnity which varies, according to the importance of the error, between 1 and 40 lire.

The men who hand in quickly objects of value or documents which they find in carriages, stations, on the line or in other places belonging to the railway, are entitled to a premium which is fixed in each case according to the value of the object found.

In addition to the allowances whether fixed or proportional to the work done nearly all the railway administrations give their staff other benefits with the object of stimulating or rewarding zeal, attention, initiative, etc.

These advantages consist in grants, special promotions, congratulatory notices published in the staff bulletin, honorary recompenses, etc.

The Italian State Railways are in the habit of distributing special recompenses to reward particular merit of such men on the occasion of exceptional services or work of a particularly difficult kind, etc. It also distributes general awards, for the whole of the staff not unworthy thereof, at certain periods of the year.

As regards special promotion, committees appointed for this purpose determine each year the value of output of the staff and suggest those among them considered to merit a promotion or exceptional increases in pay.

Promotion in the grades are then granted according to the places available; exceptional increases in pay are granted each year to a certain percentage (5 % approximately) of the men who in each group have no right to the normal increase in pay.

6. *Participation of the staff in the profits of the undertaking.*

The direct participation of the men in the profits of the working of a railway have not had in general more than a very limited application for it is very difficult to decide in what measure the men individually or in groups contribute to the earning of the profits.

In the Italian Administration an arrangement is at the present time in force according to which the staff are given a part of the difference between the ordinary receipts and the ordinary expenses of the year without consequently taking into account the general establishment charges.

The proportion set aside for the staff corresponds to ten per thousand of this difference, and is used to reward, if need be, exceptional services or special merit. In any case this sum each year cannot be less than 6 000 000 lire.

Another amount corresponding to 10 % of the amount indicated above is left at the disposal of the Minister to reward the men of grades higher than the second or similar thereto because of their contribution to the saving and to the regularity of the working of the system.

As can be seen it is not a true participation of the staff in the profits but a recompense which can as a whole vary according to the financial results of the working.

IV. — Social works.

Social works have in general received considerable development because it is easy for railway administrations to make provision therefore owing to the financial means they usually dispose of and because they realise more and more the importance of this method of attaching the staff to the employer.

The Administrations can in fact show in this way that they do not content themselves with considering a man solely for the work he does but that they look after him in his various social requirements by helping him in sickness, by giving him allowances proportional to his family charges, by facilitating the education, and hygienic care of his children and finding them employment, by helping him with money and loans when he finds himself in difficult financial circumstances, by making easy the purchase of food, clothes and even of houses, by also favouring his desire for culture, his taste for sport or amusement, and finally by assuring him a pension when he has to retire from the service.

A. *Health service.*

The Italian State Railway Administration has a special health office which employs about 60 doctors on the staff and 1 700 assistants responsible for the medical examination of recruits, or checking the particular suitability of recruits for various purposes, or visiting the staff at periodical intervals or with regard to pensions, etc.

Men employed by the Administration are visited in case of sickness or accident by the medical officers of the Administration who decide the period of absence in view of the payment of the salaries that the men continue to draw during their absence up to a maximum of 180 days.

The special payments alone which depend upon the actual presence at work (additional allowances) are lost by the employee during his days of absence through sickness. But to avoid the appreciable harm the men would suffer during absence, that is to say just when they have the greatest need for help, the Administration has decided that after the 16th day of illness and so long as the men draw their pay the insurance fund (cf. page 1250) shall pay them a daily allowance which will make up the loss of the special allowances.

In order that the insurance office may be in a position to carry out this work the employees have to make a monthly subscription equal to 2/10ths of the allowance which each of them receives during a day's sickness. In this manner the measure with which we are dealing enters into the category of mutual insurance funds.

The health service of the Italian Railways also provides without charges, to certain classes of men, surgical assistance and the supply of pharmaceutical products and of orthopedic appliances.

It also makes provision in certain special cases for sending into hospital the men or members of their families.

The Italian Administration has no hospital of its own as have other Administrations (Japanese Railways for example) but it has contracts with hospitals and sanatoriums which grant special facilities to its employees.

The health service gives special care to the cure of fever by the construction of buildings and the distribution of means of protection against mosquitoes and the free supply of anti-fever remedies.

For the treatment of malaria alone the Administration carries an expenditure each year of about 2 000 000 lire (including 1 000 000 for protective work) while the total cost of the health service reaches 5 000 000 lire per annum.

B) *Assistance and loans.*

In order to assist their men who find themselves in financial difficulties, the Italian Railways grant, after careful examination of each case and without any character of continuity, monetary help from a central fund included in the budget among the ordinary expenditure. This fund amounts to about 2 000 000 lire.

In addition, from the fund of the year's working, loans can be granted for a sum not exceeding half the monthly pay; they are paid without interest and are repaid by six successive amounts held back from the monthly pay.

In accordance with the terms of a law applying to all the employees of the Italian State, railwaymen can, for a maximum period of five years, have a part of their net salaries held back, the amount so held back not exceeding a 5th of their pay, in order to procure loans of money. This operation commonly known as « *subtraction of a fifth of the pay* » is facilitated by the Administration which uses for this purpose funds available for pensions and financial assistance and which at the present time have for this purpose a sum of 172 000 000 lire. The employees can moreover, with the approval of the Administration, borrow money from the savings bank or other credit institution or insurance company.

C) *Family allowances.*

The Italian State Railway Administration endeavours to lighten the family charges of its men by granting them a special supplement of pay in proportion to the number of persons dependent on them. This supplement (family allowances) is regulated by the terms of Law No. 1047 of the 27 June 1929 and Decree No. 1725 of the 31 December 1930. It is only granted to men of the lower grades, when married with children who are minors and varies according to the number of children; the rate is doubled for each child above three. The amount varies with the importance of the area in which the man resides.

D) *Assistance to the children and orphans of employees.*

In order to assist in another way the families of the men, special institutions have been set up (Victor Emmanuel III and Helen of Savoy Foundations) : thanks to gifts and public subscriptions

these have the necessary means for granting scholarships to the children of the men either in active service or retired and to orphans, to send them to schools or to hospitals, to send them to the mountains or the seaside. The annual cost amounts to a about 700 000 lire.

As far as possible, preference is given to the sons of the men when recruiting the staff.

E) *Facilities for purchasing food and clothing.*

Other facilities have also been granted to the men to assist them in purchasing food of the most usual kind, clothes and domestic equipment.

In 1925, attached to the Stores Department of the Administration, a special section has been set up with money advanced by the Administration, to provide for the men the more usual foodstuffs : it consists of a central office and several distributing centres (276) in nearly all the principal centres of the peninsula. The foodstuffs (at the present time about 150 items) are naturally bought in large quantities and directly from the producers.

The sale is always against cash at prices lower than those at the local shops.

The sale figures for the financial year 1930-31 amounts to about 53 000 000 kgr. (116 600 000 lb.) of commodities of a total value of 175 000 000 lire.

The supply of clothes and other domestic objects to the men is worked through an independent institution, the *Italian Consortium of manufactured products* which also purchases directly from the producers. The men can purchase what they want either against cash or on credit up to an amount of 800 lire. To repay the Consortium the Administration holds back from the men's pay each month amounts which must not exceed 100 lire.

F) *Housing facilities.*

The Administration has accomplished an important work to assure its staff having healthy housing at low rates. The measures taken with this object have been of various kinds.

Above all at the stations and along the lines housing has been prepared for the men who are obliged to live at the place where they work; the System has about 20 000 serviceable buildings of this kind.

We must call attention to the buildings, real townships built with anti-earthquake arrangements at Reggio, Messina and other important centres of Calabria and Sicily as a result of the earthquake of the 28 December 1908, and those built at Avezzano and in other localities of the region after the earthquake of the 13 January 1915.

At Reggio, in Calabria, an important railway centre at which about 1 300 men live, the buildings that have been built number 300 and include 865 apartments with a total of 3 150 living rooms.

At Messina, another important railway centre at which about 1 400 men reside, 268 buildings have been erected with 633 flats and a total of 2 100 living rooms.

The buildings in question are built at the capital cost of construction of the lines and are consequently considered as an integral part of the railway property.

The staff of the working departments of certain grades and certain functions is obliged by the Administration to live in the apartments put at their disposal or in particular houses immediately near the place at which they habitually work.

In the first case, the man has an amount deducted monthly from his pay for rent at the rate fixed by the « Regulation concerning the various accessory allowances of the staff » approved by law.

In the second case, on the contrary, he receives a monthly allowance for rent.

For sufficient reasons the Administration can allow its men to give up the apartment set aside for them in the railway company's buildings, but in this case they lose their right to any payment.

From the time that the State first began to undertake the management of the railways, the Administration recognised the advisibility of being able to offer to its staff a greater number of apartments than it could have obtained with its own monies.

A special law in 1907 authorised the Administration to set aside part of the balance of the pension fund and the staff assistance fund, up to a total of 30 000 000 lire for the construction or the purchase of houses at low rents for the staff. The interest on this sum was fixed at 3.75 %. Subsequent laws authorised other expenditures with the same object to a total which today amounts to 370 000 000 lire.

These sums are considered as lent to the Administration which has to take it upon itself to pay them back in 50 years, after which it will remain the owner of the houses built.

These houses known as « Railwaymen's cheap houses » have been built by the Administration which looks after their maintenance and lets them to its men according to the regulations in force.

The rent is fixed in such a way as to cover the costs of administration, of upkeep and of interest on the money tied up; the interest is fixed at 3.75 % for a large part of the capital and for the other part at rates varying between 5 and 5.50 %.

It should be noted also that in addition to the facilities indicated, the low interest on the capital, the amortisation for which the Administration is responsible and the principles of economy which this inspires in the management of the undertaking, the houses in question profit by all the general advantages granted by the Italian laws in regard to workmen's houses : freedom from taxes, facilities in order to obtain the land required quickly and at little cost, etc.

It is as well to indicate that, to encourage the tenants to keep their dwellings in good order and diminish in this way the expenses under this heading, the Administration grants money prizes to those who distinguish themselves by the care they give to their habitation.

The total percentage of the staff at the present time living in the buildings belonging to the Administration or in industrial housing is about 27 %.

After the world war, in order to facilitate the development of building schemes and to assist its men to purchase suitable houses at reasonable prices, the Italian Government encouraged the formation of co-operative societies of the men by advancing them the necessary capital for building purposes and contributing towards the payment of interest.

The activity of these co-operative societies was subject to the supervision of the State and suitable arrangements assured the respect of the social objects in view, the principal of which was the construction of cheap buildings which should be healthy and substantial. So in Italy numerous co-operative societies were formed in this way, which in addition to lending money at low interest and in which the State shared in the payment of the interest, enjoyed large fiscal exemptions and various facilities which enabled them to obtain building land rapidly and at low costs and to get moderate construction costs.

The Italian Railway Administration wished to contribute to the solution of the housing crisis and to favour the setting up of co-operative societies composed exclusively of railwaymen.

Besides the general steps taken by the State, it caused supplementary arrange-

ments to be started whereby the railwaymen cooperatives were assured of the financial means required to carry out their construction programme, a special contribution being made to them by the State ; it also granted them certain advantages which tended to lower the cost of construction : rebates on the cost of transport of the workmen, materials and tools, sidings between the building sites and the nearest railway line or the nearest station, carrying out of necessary work at the cost of the labour alone without charge for equipment used temporarily.

The total sum lent to the railwaymen's co-operative building societies amounts to about 515 000 000 lire, 160 000 000 of which were borrowed from the special funds of the Administration, the rest having been granted by the State.

The rate of interest on all this capital was fixed at 4 %, but as the State took over a part equivalent to 2.75 %, the members of the co-operatives only had to bear 1.25 %, the cost of administration and of amortisation of the capital, which must be completed in 50 years.

The law requires, however, that the co-operatives can at any time free themselves from their debt to the State or the Railway Administration by paying a capital sum equal to the actual value of the amortisation payments still due, calculated according to the rate of interest on the money loan at the time; they can therefore cancel their debt at the beginning of the amortisation period by paying about 42.5 % of the price of the building, and at any other moment by paying a percentage which added to the sums already paid off always amount to 42.5 % of this price.

Thanks to the measures mentioned above, up to the present time there has been built over the whole Kingdom about 5 500 buildings with 38 000 rooms for railway employees. There are 90 buildings with more than three stories above the ground floor, with two or more apartments on each floor ; 172 buildings with three floors at most including the ground floor and two or more apartments at most on each floor; 100 are of the type in which the ground floor and the first floor form one apartment; 1 061 are semi-detached villas, and 451 detached villas.

G) *The Railway Afterwork Society « Dopolavoro ».*

In 1925, on the direct initiative of the head of the Italian Government the *National Afterwork Care Association « Dopolavoro »* was set up with the object of « encouraging the healthful employment of the leisure hours of the men by institutions which would develop their physical capacities, their intellectual abilities and their moral character ».

The movement had a special application in the railways of the State where the Dopolavóro rapidly developed, thanks to the industrial character of the Administration, the flexibility of its working, the possibility of quick and direct communication between the centre and the district branches, the existence in the district of centres of command which are not only capable of interpreting with intelligence and common sense the orders received but which can also closely supervise the prompt, full and exact carrying out of the work ; the discipline re-established in the railway ranks, as the result of Fascism, the spirit of comradeship which now united them to the extent of making them into one immense family, were also contributing factors.

The « Dopolavoro » of the railways to which nearly all the employees of the Administration, to the number of about 150 000, belong, is controlled by a central office the headquarters of which is at Rome, and has 14 district offices, one for each of the divisions of the system.

The various organisations of the Do-

polavoro were distributed over the whole system and amount today to 265.

The Railway Dopolavoro has its own funds (about 4 000 000 per annum) mostly supplied by the Administration (fixed annual contribution of 800 000 lire plus 10 lire per member) and it deals with it under the control of a central committee. Its activity is exercised more especially in the following directions :

1. Assistance, domestic life and health;
2. Agriculture;
3. Culture and education;
4. Recreations and sports.

In addition to the men on the pay sheet, it was subsequently decided to admit as members men who had retired, and as *associate members* the sons of members, to enable them to frequent the schools, the gymnasiums and the sports set up by the Dopolavoro.

The railwaymen, as regards the Dopolavoro, find themselves in very different positions according as to whether they live in populous centres or along the lines right in the country. The former, who today number about 90 000 are grouped in institutions completely organised and equiped. The others are isolated and by their voluntary contributions continue to support the organisation while only profiting by a part of the advantages that it offers to its members.

These latter, who represent about 40 % of the members are the object of the particular preoccupation of the Rome office which endeavours by all possible means to reach them by means of a series of special measures. This is necessary, because whereas those who are grouped together in societies, circles or other organisations can find in these a source and a reason for distraction, of culture or in any case of healthy and profitable occupation for their spare time, the isolated members of the staff (which is the reason why they have the greatest need of being assisted and helped) cannot or can only with difficulty succeed in this object.

The most important divisional section of the Dopolavoro is naturally that of Rome which has a special building with a theatre, gymnasiums, fencing shools, libraries, and even a hotel with its restaurant.

H) *Holidays and free passes.*

Among the other advantages which are granted to the railway employees the various Administrations allow as a rule *annual holidays with pay* and a certain number of *free tickets.*

The Italian Administration grants every year to its men a holiday of 26 days for the upper grades and 16 days for the lower grades. During this holiday the men draw their usual pay or salary without the supplementary allowances.

For exceptional reasons the men can also get special holidays with half pay.

As regards free tickets the Italian Administration grants to its employees and their families 3 free tickets each year and an unrestricted number of permits at half rate.

I) *Pensions.*

The grant of an old-age pension after a certain number of years of service or as a result of infirmity is now admitted by nearly all Railway Administrations.

The permanent staff of the Italian Railways has a right to a pension after 20 years' service.

In the event of the death of an employee before he is entitled to a pension, his family (wife and children under age) receive the part of the pension known as the repayable part, i.e. 50 % of the pension that would have been paid to the man, if the widow is left alone; it can be as much as 75 % if there are children under age.

The age limit at which the staff is retired varies between 58 and 66 years according to the grade and position.

The annual amount of pension cannot exceed 8/10ths of the average pay received during the last three years of service nor be less than 1 800 lire : it is calculated by taking as many fortieths of the pay as the man has years of actual service for the first 8 000 lire, and for the sums above this, as many fiftieths as he has years of service.

Consequently the pension after 30 years service of a man receiving 8 000 lire pay reaches about 3/4 of his pay when at work.

It should not be forgotten that the rate of pay upon which the pension is calculated is lower than the total pay while in service because, as a rule, no account is taken of gratuities and supplementary allowances.

The Italian Administration at the present time is paying out for pensions and allowances ni connection with the increased cost of living as well as for assistance to the employees and their families a sum of about 500 000 000 lire.

The reserve for pensions amounts to about 1 175 000 000 lire which produces an annual interest of about 50 000 000 lire. The contributions from the men in the service (based upon 6 % of their pay) at the present time produces about 85 000 000 lire.

The difference, i.e. 365 000 000 lire, between the sum available (50+85= 135 000 000) and the total amount of pensions and assistance is made up by the Administration which is in addition obliged by the regulations in force to contribute annually 40 000 000 in order to build up the pension reserve fund.. This contribution will be paid for as many years as is necessary to bring up this fund to such a figure that the interest will be sufficient to meet the annual pension payments, in conjunction with the contributions of the staff and a contribution from the Administration equal to 52/100 of the total amount of pension and assistance.

The burden falling upon the Administration at the present time under this head amounts to 405 000 000 lire a year which represent 18 % of the total expenditure on the staff.

In addition to the pensions the Italian Administration with truly paternal care has sought to assist its employees at the difficult moment when they pass from active service to retirement, and even more so to assist, in the way shown hereafter, their families when they lose their head.

L) *Mutual assistance for retired servants and the families of men in the service.*

In 1913, a *Mutual Assistance Organisation in favour of the staff of the State Railways* was set up, one of the most important functions of which was to grant a payment known as the « good sendforth » to employees on the staff, when for any reason they are retired, or to their families, should the employee die.

All the staff belong to this organisation to which they contribute 17 per thousand of their pay. The Administration on its side provides the organisation with other revenues so that it can provide not only the allowance mentioned above, but also for still other objects of the highest good for which it was set up and which are:

— Subsidies up to 18 years of age to orphans of the men not entitled to a pension;

— Allowances to support relations who had no right to pension but who during the life of the man were dependent on him;

— Placing orphans in educational establishments;

— Scholarships for orphans and for children of men who have retired or who are still in active service;

— Payment of daily allowances to employees who are ill, after the 16th day of illness.

The Mutual Assistance Organisation

by the 30 June 1931 had a capital amounting to more than 100 000 000 lire.

It paid out during the financial year 1930-31 about : 45 000 000 lire for retiring allowances, 14 000 000 for assistance and relief to families and for cost of education of orphans and children of the men, and 2 500 000 for daily allowances in cases of illness.

Summary.

For the reasons given in the foreword, the reporters have not been able to examine the subject proposed over a wider field of enquiries, as was necessary to be able to draw useful conclusions.

None the less the examination of the limited material at our disposal makes it possible to state that railway companies, even in the particularly critical moment they are passing through, take steps to extend the application of the most important principles of organisaion as well as those best known to every branch of their activity, — in particular, those applications which in the general framework of the scientific organisation of work have had some effect upon improving the output of the human element.

The differing forms of government, the variations in working surroundings, the character and habits of the subordinate staff have their influence upon the line followed : thus it would seem, as a general rule, to be of little practical value to endeavour to fix uniform regulations in this connection.

The one thing which, as a rule, it would seem to be possible to recommend to all administrations is that of developing amongst their men a more delicate sense of responsibility and of devotion to duty.

The railway service can, with good reason, be considered as the most important public service of the nation, even in the face of the rapid growth of other more recent means of transport.

Upon the proper working of the railway service depend the vital interests of a country; thus the large companies which control the most important railways of a state should take steps to initiate their staff into an understanding of the most important social duties.

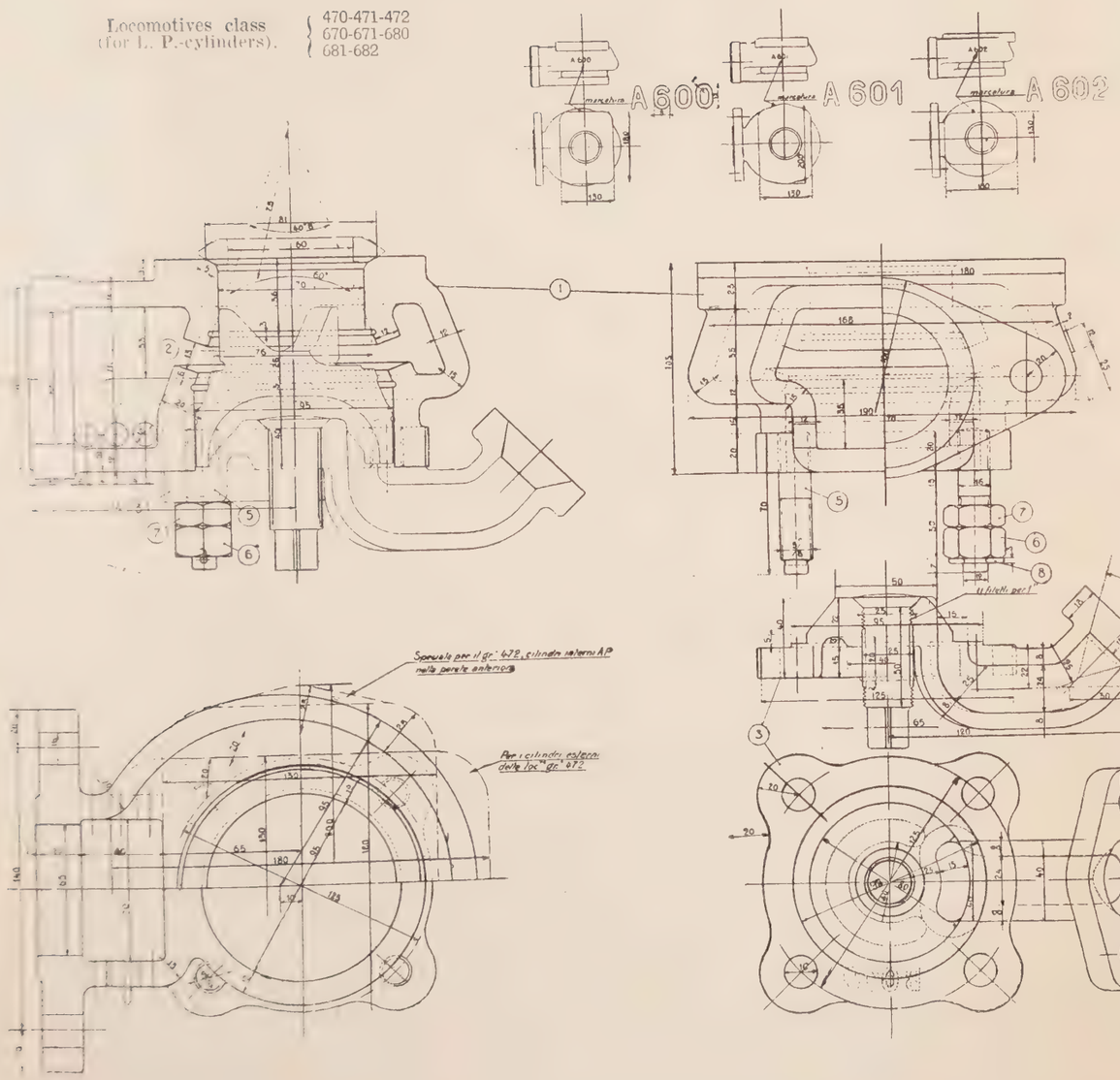
The Italian State Railway Administration considers the discipline of its staff as a refined application of its civil duties : this is the undertaking that every man signs loyally when beginning his service.

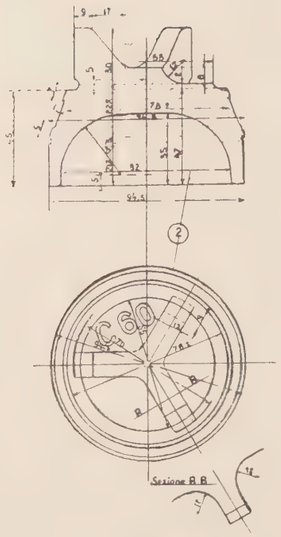
He undertakes, in fact, on oath, to fulfil all the duties attached to his occupation with diligence and with zeal for the good of the public and in the interests of the Administration, while keeping scrupulously professional secrecy and conforming his behaviour, even when off duty, to the dignity of his employment.

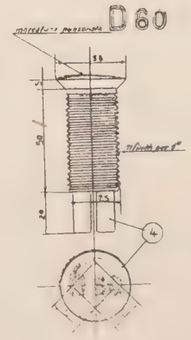
Such high feelings can manifest themselves most fully under working conditions in which the man feels himself to be guided by energetic and capable superiors, sees himself aided rather than supervised in doing his work, helped in a paternal manner at difficult times and finally understands that his well-being is indissolubly connected with the prosperity of the Administration employing him.

60-mm. multiple valve.

Locomotives class (for L. P.-cylinders): { 470-471-472 / 670-671-680 / 681-682







Machining sheet nº 3-IV-1

Number.	DESCRIPTION.	Material.	Quantity per valve.	Remarks.
1	Body	Cast iron, class II.	1	
2	Valve	Cast steel.	1	
3	Cover	Cast iron, class II.	1	
4	Plug	Bronze.	1	
5	16-mm. stud . . .	Homogeneous iron, class II.	4	
6	16-mm. nut . . .	Homogeneous iron, class II.	4	
7	Check nut . . .	Homogeneous iron, class II.	4	
8	Split pin	Homogeneous iron, class II.	4	

Explanation of Italian terms:

Marcatura = Mark. — Speciale... = Special pattern for series 742 (inner) high-pressure cylinders, in the front wall. — 11 filetti per 1" = 11 threads per inch. — Marcatura particolare = Stamped mark.

60-mm. multiple valve.

Subhead of machining sheet.	Heading.	DESCRIPTION OF THE WORK TO BE DONE.	Number of subheading.	Unit counted.	Time in hours and hundreths. Forging.	Turning.	Planing and milling.	Drilling.	Fitting.	Heading of the nomenclatures for the part of the materials to be used in making or machining the part (3).	Class number.	Order number.
I.	3.320	**Valve body** (1).								Body A 600, in cast iron, for 60-mm. valve.	122	170
										Body A 601, in cast iron, for 60-mm. valve.	»	171
		Turn joint flange and hole for compensating tube faces, inside chamber and valve seats, drill discharging holes, stud holes, in cover and for compensating tube bolts, prepare, tap holes and drive cover studs	12	Body	...	7.83	....	0.80	2.00	Body A 602, in cast iron, for 60-mm. valve.	»	172
II.	»	Drill holes for cylinder securing studs, mark out, tap holes, drive studs, fit to cylinder (2).										
		Outer cylinder	1	»	...	...	...	0.40	1.67			
		Inner cylinder	2	»	...	...	...	0.40	1.75			
		Moveable valve (turn, fit and grind).										
III.	»	rough casting	39	Valve	...	2.92	...	...	0.40	Moveable valve, C 60, in rough cast iron, for body of 60-mm. multiple valve.	»	168
IV.	»	supplied machined	42	»	...	1.58	..	...	0.40	Moveable valve, C 60, in mild steel, forged and rough-ground, for body of 60-mm. multiple valve.	»	169
V.	»	**Cover** (turn face of joint, the screwed hole for the plug and flanged connection, drill holes for connection to body and holes in the flange, set and fit to body)	54	Cover	...	3.92	...	0.45	0.53	Cover B 600, in cast iron for 60-mm valve.	»	173
		Closing plug:								Cover D 60, in bronze, for 60-mm. valve.	»	174
VI.	»	in bronze (turn and screw from cast bar, square the tail piece by planing or milling, fit)	59	Plug	...	0.50	0.33	...	0.20	Bronze, B quality, in round ingots of 60-mm. diameter, 0.530 kgr.	416	211
VII.	»	in iron (smith, turn, screw, square the tail piece by milling, fit)	59	»	0.25	0.50	0.33	...	0.20	Homogeneous iron, 2nd class, in 55-mm. round bars, 0.500 kgr.	86	157

(1) Not including drilling and driving cylinder fastening studs.
(2) The same times are applied to bodies supplied machined.

(3) **Note:** Complete F. S. 60-mm. multiple valves with { A 600-B 600-C 60-D 60, class number 122, order number 165. / A 601-B 600-C 60-D 60, class number 122, order number 166. / A 602-B 600-C 60-D 60, class number 122, order number 167.

MINISTRY OF COMMUNICATIONS.

Italian State Railways.

Rolling Stock and Locomotive Running Department.

APPENDIX 2.

Siding ..... **Departure time** ..... **Date issued** .....

Sezione	Impianto	Anno	Mese	Debito o credito	Operazione	Ordinativo	Commissione	Rotabile	Riparto di lavorazione (Mestiere)	Gruppo agenti	Voce lavoro		Tempo assegnato ore	Tempo assegnato cent.	Tempo impiegato o assenze ore	Tempo impiegato o assenze cent.
				1	3		0 0 0 2		0 3		4 0 9					
1 2	3 4	5	6	7	8	9 10 11 12	13 14 15 16	17 18 19 20 21 22 23	24 25	26 27 28	29 30 31	32 33	34 35 36 37	38 39	40 41 42 43	44 45

Workmen and labourers who carry out the work.

Number of heading.	HEADING IN THE RATES BOOK. **Iron smoke tubes, smooth, 52 mm. outside diameter.**	Unit counted.	QUANTITY at issue.	QUANTITY actual.	TIME ALLOWED unit. Hours.	unit. Hundreths.	at issue. Hours.	at issue. Hundreths.	Actual after additions or alterations. Hours.	Actual after additions or alterations. Hundreths.
4.280	Scaling tubes in rumbler, including straightening when needed	Tube			0	03				
4.282	Select and examine tubes for repairs	»			0	035				
4.283	Reduce tubes to given dimensions and cut — at one end	»			0	03				
	— at both ends	»			0	07				
4.291	Unsolder at fire broken pieces, separate two metals and select copper rings usable	Piece			0	027				
4.285	Apply rings by hard soldering — 1 iron ring	Ring			0	43				
	— 1 copper ring	»			0	38				
4.286	Apply rings by autogeneous welding. — 1 iron ring	»			0	18				
	— 1 copper ring	»			0	20				
4.284	Make hydraulic test	Tube			0	07				
4.288	Hand stamp repaired and tested tubes	»			0	007				

Issuer .....

Supervisor who authorised alterations .....

Total time allowed at issue of order.

Work examined at ..... **(time) on (date)** | **Checked by:** .....

The technical assistant .....

Total time allowed finally . .

Explanation of Italian terms:

Sezione = Section. — Impianto = Shop. — Anno = Year. — Mese = Month. — Debito o credito = Debit or credit. — Operazione = Operation. — Ordinativo = Work order. — Commissione = Commission. — Rotabile = Locomotive or vehicle. — Riparto di lavorazione = Division or trade. — Gruppo agenti = Group of workmen. — Voce lavoro = Class of work. — Tempo assegnato = Time allowed. — Tempo impiegato o assenze = Time taken or absence. — Ore = Hours. — Cent. = Hundredths.

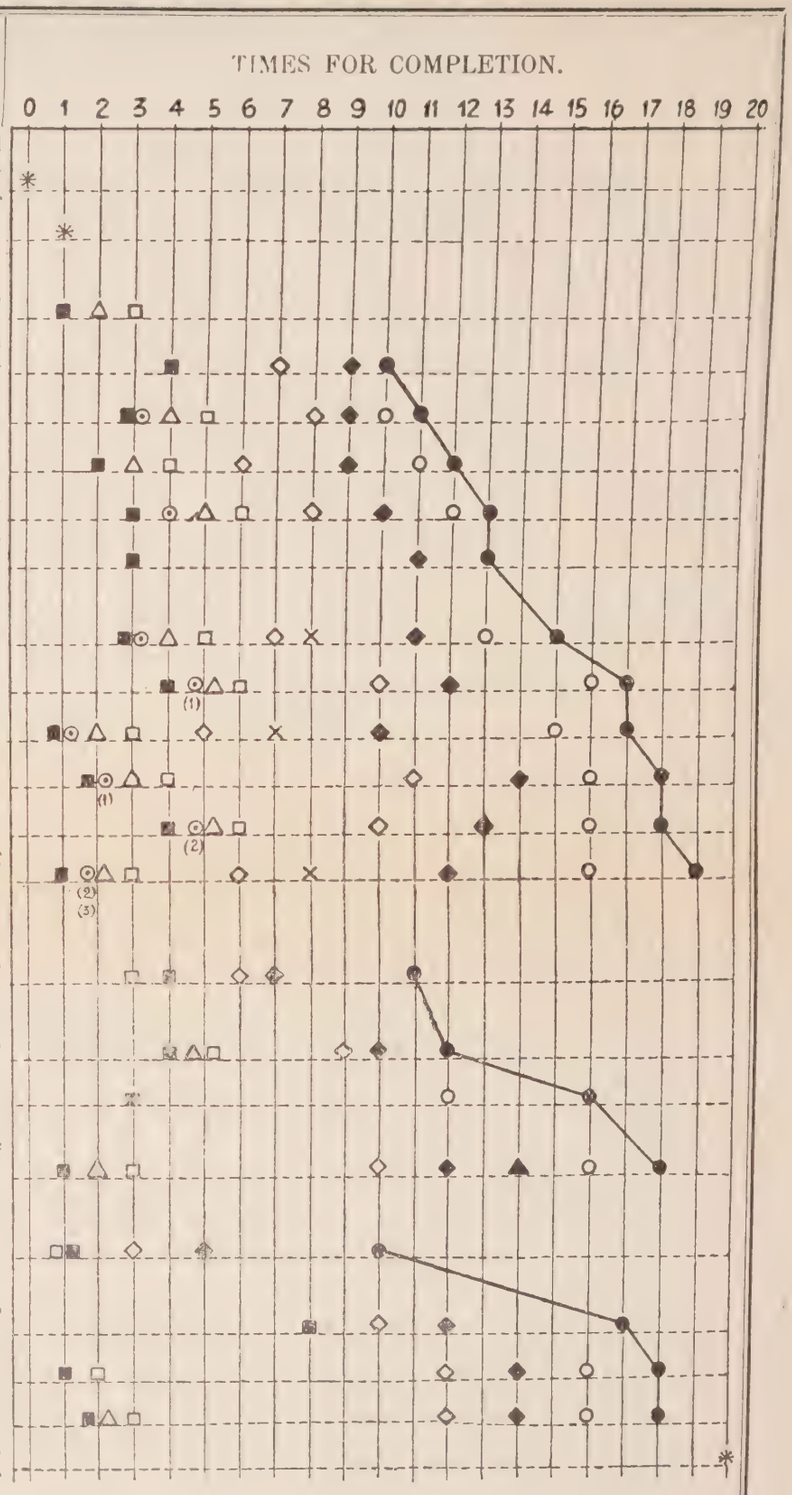
1255
X—45

Type diagrams of work for the intermediate repairs of locomotives.

Meaning of conventional signs.

- ✱ Preliminary operations for which the depot is responsible. Sending in for repairs. Trial run.
- ■ Completion of erection.
- □ Completion of stripping. Sending parts to be repaired to different sections.
- --- Co-ordinating, control of the times and examination.
- ⊙ Completion of work of taking apart details taken out of service.
- ● Completion of repairs in hand and erection.
- △ Completion of cleaning.
- × White metalling and remetalling.
- ○ Machining groups at benches.
- ◆ Lathes and machine tools
- ◇ Smiths fires, autogeneous welding, boiler work.
- ⋏ Coppersmiths.

} Completion of return of manufactured or repaired parts and of fittings reassembled and tested.



DESCRIPTION OF WORK.

- Removal of fittings, emptying sand boxes, thorough external cleaning, washing out, cleaning firebox, ashpan and smokebox
- Sending in for repairs
- Main frame and bogie frame: Lifting, cleaning, examination, squaring up, checking main cylinders, and valve chests, removing lagging
- Main frame and bogie frame: Repairing and if required changing horn sheets and different carrying brackets, replacing wedges, welding cracks
- Draw and buffer gear
- Springing (equalisers, hangers, bolster, centering gear)
- Brake cylinders, triple valves, double isolating valve, train pipe
- Boring out cylinders and valve chests (changing valves if necessary)
- Pistons and piston valves, piston rings, crossheads and slides, slide bars and brackets
- Brass work, injectors and piping
- Axles, axle-boxes, stays and wedges, wheeling main and bogie frames
- Regulator and handle, dome, safety valves
- Westinghouse pump, brake valves, main lubricator
- Brake gear (2), sand gear (2), coupling and connecting rods (2), speed recorder and driving gear (3)

- Main frame and bogie frame (replacing rivets and bolts, different brackets, drag boxes, headstocks, painting)
- Header, swan neck stays, cleaning boiler, inside and outside, repairs to tube plates, barrel
- Nest of tubes
- Exhaust, steam pipes, superheater elements, completion of smoke box

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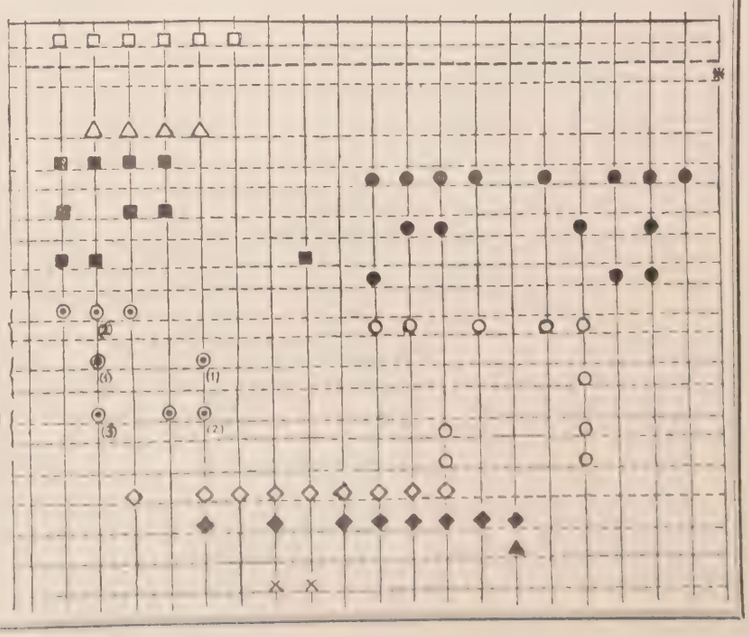
- Examination of firebox, fusible plugs, vertical roof stays
- Copper stays, repair by autogeneous welding of firebox sides, completion and checking work carried out
- Fire box door, repairs to door frame
- Generator, grate, casing, delivery box
- Final adjustments and preparing for trial run, lighting up, test run

DISTRIBUTION OF WORK.

Locomotive n°.....

Stopped for repairs on.....

- Organisation: Stripping
- Organisation: Co-ordination, checking times and inspection
- Organisation: Test run
- Handling, cleaning
- Execution: Stripping, repairing and erecting gangs: Fitters: Stripping
- Execution: Stripping, repairing and erecting gangs: Fitters: Repairs and erection
- Execution: Stripping, repairing and erecting gangs: Boiler-makers: Taking down
- Execution: Stripping, repairing and erecting gangs: Boiler-makers: Repairs and erection
- Execution: Gangs for machining at the benches: Fitters: Running gear, motion, spring gear, brake gear
- Execution: Gangs for machining at the benches: Fitters: Brass work, regulator and safety valve
- Execution: Gangs for machining at the benches: Fitters: Westinghouse brake fittings and special fittings
- Execution: Gangs for machining at the benches: Boiler makers: Preparing tubes and miscel
- Execution: Auxiliary services: Smiths and autogeneous welding
- Execution: Auxiliary services: Turners
- Execution: Auxiliary services: Coppersmiths
- Execution: Auxiliary services: Lining with anti friction metal



Electric locomotive shops.

Genoa-Rivaloro.

Programme for general repairs of E 431 locomotives.

Shops.	Divisions.	N° of job.	Stages and work places. / Description of work.	Yard. 1st Stage.	Shop No. 3, road 4. 2nd Stage.	Shop No. 1, 1st road. 3rd Stage.	Shop No. 2, roads 4-5. 4th Stage.	SHOP N° 3 — roads 1-2-3-4-5. 5th Stage.	Shop N° 1, roads 2-3-4-6-7. 6th Stage.	Shop N° 2. roads 3-4-5-6. 7th Stage.	Shop N° 1, roads 2-3-4-6-7. 8th Stage.	Shop N° 2, roads 1 and 2. 9th Stage.	Preliminary. Trial. 10th Stage.	Shop N° 2, roads 1 and 2. 11th Stage.	Yard
			ERECTION AND MACHINING IN HAND.												
2		1	General taking down												
—		2	Cleaning frame and cab												
—	2	3	Repairs to frame and cab												
—	"	4	Repairs and erection of parts of frame (1). Setting horn blocks (2). Completing frame (3)												
—	"	5	Erection of spring gear, motion, brake. Repair and erection of sand gear (1)												
—	"	6	Erection of traction motors (1). Outside brasses (2). Rotation tests (E)												
—	"	7	Erection of Westinghouse brake valves. Repair and erection of air reservoir, examination of brake cylinders (1). Repair and erection of iron piping (2)												
—	"	8	[illegible] cabin extensions [illegible] screens fastenings. Repair and fitting of oil cups (1)												
—	1	9	Mechanical erection of electrical equipment												
—	"	10	Erection of electrical equipment. Tension tests (T.)												
—	"	11	Adjustment of the trolley												
—	2	12	Taking down floor and stands. Installing motor cable tubing (2). Fitting flooring in cabins	1											
—	"	13	Painting frame (1). Scraping and cleaning (2). Rubbing down (3). Bearing of the trolley, by hand (4). Finishing (5)												
			FITTING AND ERECTION AT THE BENCHES.												
2		3	Bogie frames												
—	3	21	Wheel sets, brasses, boxes (1). Horn sheets when needed (2)												
—	3	22	Spring gear (1). Safety hangers, brake gear (2). Fastenings (3)												
—	3	23	Rods												
2	1	24	Motor windings (1). Auto transformer (2)												
—	—	25	Traction motors: Collectors												
—	—	26	Traction motors: Controller												
—	—	27	Traction motors: Contactor												
—	—	28	Traction motors: Outside bearings, pins and rings (1). Counterweights (2)												
—	—	29	Traction motors: Erecting stator and rotor, fitting bearings. Repairing casing. Rotation test in cabin (R.)												
	2	30	Cabin extensions (1). Chests, screens, etc. (2)												
—	1	31	Tools and fittings												
3	2	32	Rheostat cupboard (1). Cooler, vaporiser, water tanks (2). Coils (3)												
—	1	33	Elements of rheostat												
—	—	34	Westinghouse brake fittings												
—	—	35	Electric and mechanical compressors												
—	—	36	Motor pumps and fans												
—	"	37	Auxiliary motors												
2	"	38	Transformers												
"	"	39	Automatic and change-over switches (1). High tension circuit breakers (2)												
"	"	40	Control tables. Trolley operating valves. Commutators, fans, compressors and rods												
"	"	41	L. T. frame. Phase changer. L. T. switch and commutator												
"	"	42	Rheostat top, wattmeter, brushes, etc. Safety devices. Relays												
—	"	43	Measuring instruments												
—	"	44	Brush holders												
3	2	45	H. T [illegible]												
"	1	46	H. T. cable (1). M. T. cables (2). L. T. cables and for measuring intruments												
—	—	11	Trolley												
			ACCESSORY OPERATIONS AND WORK.												
—	—	—	Taking down, at the benches												
—	—	2	Cleaning, at the benches												
—	P.C.I.	—	Stripping												
2	1	51	Sanding												
1	3	52	Smithing												
—	2	3	Electric and autogeneous welding												
3	"	30.32	Miscellaneous boilersmith's work												
			Lathes and machine tools												
			Turning frame rivets and bolts												
—	3		White metalling												
—	3		Tin smithing												
—	2	13	Painting												

Days immobilised per stages and work places.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

CONVENTIONAL SIGNS.

- ■ Sending in parts from general taking down section.
- ● Completion of taking down, at the benches.
- △ Cleaning, done by gangs at the benches.
- ▲ Cleaning, at the benches, done by the gangs cleaning the frame and cab.
- □ Stripping.
- ◇ Sending parts for: Smithing, electric or autogeneous welding, boiler work.
- ◆ Sending parts for: Lathes, machines tools.
- ◘ Sending parts for: Turning frame rivets and bolts.
- ◙ White metalling.
- × Parts supplied by tinsmiths.
- ⋈ Sanding.
- ⊠ Painting
- ○ Completion of machining of parts by the fitters and the erection gangs at the benches and completing of the erection of the said parts.
- —— Periods of machining and of erection in hand.
- —— Periods of time during which the various parts are at the disposal of the machine shop gangs. Duration of the operations and accessory work at the benches.

Electric locomotive shops.

Genoa-Rivarolo.

APPENDIX 5.

Work done in repairing locomotives.

WORK (operations).	1st stage. No. 1 outside road. Progress phase.	2nd stage. Shop No. 1, road 4. Progress phase.	3rd stage. Shop No. 1, road 1. Progress phase.	4th stage. Shop No. 2, roads 4 and 5. Progress phase.	5th stage. Shop No. 3, roads 1, 2, 3, 4, 5. Progress phase.	6th stage. Shop No. 1, roads 2, 3, 4, 6, 7. Progress phase.	7th stage. Shop No. 2, roads 3, 4, 5, 6. Progress phase.	8th stage. Shop No. 2, roads 2, 3, 4, 6, 7. Progress phase.	9th stage. Shop No. 2, roads 1, 2. Progress phase.	10th stage. Yard and electrified roads. Progress phase.	11th stage. Progress phase.
	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.	N° Parts in hand.
General taking down	1a Removal of units. Emptying sand boxes. Taking away flooring removed.	2a Cabin extensions, locks, screens. Cooler. Water tanks, Rheostat parts. Electric and mechanical compressors. Motor pumps and fans. Trolley.	3a Bogie frames. Wheel sets. Brasses. Boxes. Safety loops. Spring gear of frames. Brake gear. Rods. Auto-transformer. Brush holders. Control table. L. T. frame. Phase changer. Cable tubing. Cables. Safety devices. Relays. Rheostat top. Regulating wattmeter. Circuit breaker. H. T. valve box. Commutator. Fans. Compressors. Rods.	1a Traction motors. Coils. Transformers Automatic primary switch. Inverter.	5a Rheostat cupboard Air reservoir. Compressed air pipe. Westinghouse brake valves.						
Cleaning frame and cabin					1a Cleaning of frame and cabin.						
Repairing frame and cabin					1a Repairing frame and cabin.						
Erecting frame details					1a Squaring up of frame. Fitting horn sheets. Erecting frame details.						
Erecting details of spring gear, motion and brake						1a Erecting running gear, spring gear and bogies.		2a Erecting hangers, brakes, sand boxes, counterweights. Rods.		3a Preliminary runs Trial runs	
Erecting traction motors						1a Turning out outside bearings of motor.	2a Erecting traction motor. Rotation tests.				
Erecting Westinghouse brake fittings, erecting and repairing iron piping					1a Erecting air reservoir. Repairing brake cylinders. Fitting up of Westinghouse brake valve.	2a Repairing and erecting train pipe.					
Erecting lockers, front extensions, screens, fastenings, oil cups					1a Repairing and fitting oil cups. Erecting cabin extensions.	2a Fitting locking devices.			3a Erecting lockers and screens.		
Mechanical erection of electrical equipment					1a Erecting rheostat cupboard, cooler, evaporator, coils, water tanks, electric and mechanical motor pumps and fans, automatic and primary switches, inverters.	2a Erecting Scott auto-transformer.	3a Erecting transformers.	4a Erecting trolley.			
Erection of mechanical equipment					1a Erecting control tables. Trolley operating valves. Commutators, compressors and rods. L. T. frame. Phase changer.	2a Erecting circuit breakers and H. T. valve boxes. Rheostat top, regulating wattmeter. Short-circuit brushes. Safety devices. Relays. H. T. and L. T. cables.		3a Erecting measuring instruments.	4a Erecting brush holders. Motor cables. Tension tests.	5a Insertion. Preliminary runs Trial runs.	
Regulating the trolley									1a Regulating the trolley.		
Joiners' work	1a Taking up flooring and taking down switchboard.					2a Fitting M. T. cable tubing.			3a Putting down floor and erecting cabin.		
Painting					1a Painting frame.	2a Scraping, cleaning and first coat.		3a Puttying and rubbing down.	4a Painting running gear and trolley details, outside of cabin extensions, etc.		5a Last coat to outside of cabin and extension. Inside of cabin. Lettering.

[656. 225.2]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION VII:

Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round.

REPORT No. 2

(Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg and Switzerland),

by O. GAEREMYNCK,

Ingénieur principal au service de l'exploitation de la Société Nationale des Chemins de fer, Belgium.

CONTENTS.

A. — Allocation of rolling stock.

I. — Definition of the problem of allocation.

The allocation of rolling stock is limited to rolling stock belonging to the companies themselves and to companies working with them, the privately owned wagons not being included. It has to take into account conditions which differ considerably from one system to another.

If as a rule railways are obliged by law to convey goods, the purpose for which they were built, in a given *order,* the law fixes in different ways the *periods within which* the wagons must be *supplied.* In some cases maximum periods are laid down, varying appreciably from one railway to another, while in other cases all that is laid down is that the wagons must be supplied as far as is possible; in still other cases, the railway has to supply them when operating conditions allow and not at a fixed time, with the condition that the goods shall be sent to destination within the period fixed by the tariffs. These requirements affect the organisation of the allocation of wagons and the stock of vehicles, although the railways do not make use of the regulations laid down as regards time except when there are disputes, but take

steps to supply the rolling stock as soon as possible; this attitude is imposed upon them by their own interests, and by competition; on many railways the practice has resulted that demands made the day prior to that when the wagons are required are met, and that all the stock is available within 24 hours, for slow goods traffic; in the case of express goods, the periods are much shorter; frequently there is no delay at all.

The above only applies to ordinary wagons; special wagons of which there are only a small number in the stock, are supplied in accordance with availability, in the order in which the demands are received, without guarantee as to time.

* * *

In order to be able, if need be, to prove that it has fulfilled its legal obligations, the railway generally maintains a register of all *wagons asked for;* the client receives, if he so desires, a receipt of his demand, which he can draw up according to his requirements, either in writing or verbally, or by telephone; he gives at the same time every useful information required to decide the *type of stock needed,* the railway company reserving nearly everywhere the right of selecting the wagon. Penalties are laid down to prevent unreasonable demands; they consist in the imposition of a tax for not using the wagon or for standing charges; these fines are only applied after careful consideration so as not to upset important customers.

* * *

An important factor is the *number of wagons to be allocated* and the number of stations between which they have to be distributed. The allocation is done naturally by type of wagon, and the number supplied varies daily for each type from one railway to another, from 100 and even less to 12 000 or so; the *number of stations* varies between 1 200 and a few dozen. Moreover, on a given railway, besides a daily number of several thousands of wagons of one type supplied daily, we find cases of two, three or four hundred wagons of another type. On a large railway system, therefore, for certain classes we find supplies of few wagons of the same order of magnitude as the number supplied (of other kinds) on small railways. But the allocation of these supplies is very different because on a large system it affects many more stations than in the case of the small companies.

* * *

The proportion of the stations where the *receipts are the greater* and those *where the despatches are greater* for each type of wagon also has to be taken into account when deciding the system of allocation to be adopted. Stations which do not exactly belong to either of these classes are nearly always the most numerous and this complicates the allocation; but on several railways, there are important mining districts, which absorb a large part of the supplies of open top wagons, or large steel works which take many platform wagons. In this case, it naturally becomes necessary to organise permanent movements to bring up supplies of wagons almost constantly.

* * *

As an organisation of this kind is of great advantage, several railways have endeavoured to extend it or to make it general. From this point of view an examination of the replies to the questionnaire reveals widely divergent ideas. Whereas the railways, even those where the number of wagons supplied is great, have not noticed any marked regularity in the supplies of wagons, others have found that the *variations in demand* show the relative constancy generally characteristic of human activity : the supplies of stock vary without wide dif-

ferences about averages corresponding to the average production of the works, mines, or average needs of trade. These averages are moreover variable to a marked degree from one season to another, or from one period more or less long to another equally long. The relative constancy in supplies appears generally over the whole of a railway; but it is also observed in important stations when considered by themselves; and if groups of average sized or small stations are examined, when situated in the same district or on the same line, the same thing is found.

On the Belgian National Railway Company's lines this observation has been used in recent years when setting up a method of allocation of stock which was very different from that followed in the past.

* * *

The examination of these few elements of the problem of allocation explains why the solutions adopted by the different railways show such considerable differences.

On the small systems, which only have to allocate a small number of wagons between a small number of stations and under rather particular conditions, the methods are simplified; sometimes it is not even a question of a method as such, the wagons being followed up individually.

In the following we have only dealt with the systems reported by the large railways, and from these we have endeavoured to bring out the principal features.

II. — Solution of the problem of allocation.

The methods in use have in common the fact that the allocation is centralised in *several stages*, according to the following scheme :

In the stations the local service allocates the wagons between the consignors.

The stations are grouped together, and at the head of each group there is a wagon distributing office which allocates the wagons between the stations of the group.

The groups of stations depend in their turn on a district formed by several neighbouring groups : at the head of the district an organisation distributes the wagons between the groups.

The district may be the whole railway, in which case the distributing organisation is the central wagon distributing office; or the railway may consist of districts in which case the centralisation is carried a degree further; when the districts can in their turn be grouped together; the new conglomerates forming the railway, which makes 5 successive stages to be considered in the system. Starting from the top, each organisation distributes between the organisation of the degree next below it.

All these organisations *communicate* between one another by written reports sent by specially indicated passenger trains, by telegraph or by telephone, public or railway, sometimes by automatic telephone, especially on lines worked by train dispatching. Where desirable all these different methods are used.

* * *

In view of the allocation, the rolling stock is classified by type, each type being more especially suitable for the carriage of certain goods. The allocation is the more complicated naturally as the number of types of wagons is greater, but this is a secondary consideration; what is more serious is that the variety of types is a cause of empty running; the stations will dispatch empty wagons of a certain class, although they have to ask for empty wagons of another pattern; further, the multiplicity of types increases the number of wagons required, the various types not being used to

the same extent at all periods : thus on certain railways, the period of heavy transports in flat wagons is out of step by several months relatively to that of the traffic in open wagons, and this latter does not coincide with that in covered wagons. If these three classes of wagons could be combined together a great reduction in the number of wagons in the stock would result. Now this stock represents a considerable capital : thus the Belgian National Railway Company owns 115 000 wagons for commercial purposes, for a railway of 5 000 kilometres (3 100 miles) in length i. e. 23 wagons per km. (37 wagons per mile), heaving a value of 5 000 gold-francs each that is more than 100 000 gold-francs per km. (160 000 gold-francs per mile). In addition each supplementary wagon involves an increase of expense for holding it in the sidings and when in the shops.

The differences between wagons of each type, as regards capacity, volume, or area and length are also harmful : they hinder getting the full use of the stock and prevent the adoption of commercial practices for using it under the best conditions.

Therefore the railways are unanimous in taking steps to *reduce the number of classes* of wagons and to make them *uniform* in each class.

* * *

Generally the wagons are grouped into three main categories :

— covered wagons,
— high sided wagons, open wagons,
— platform wagons or low sided wagons.

This latter class is often subdivided for example into 4-wheeled wagons below 20 tons, and bogie wagons of 20 tons and over; these in their turn into wagons of less than 15 m. (49 feet), and of 15 m. and over, these latter being more especially set aside for the transport of rolled sections and logs.

According to the particular peculiarities of the traffic of the different railways to the principal types others may be added, numerically less important, such as fruit wagons, vegetable wagons, cattle trucks, etc...

Almost everywhere there are appreciable differences in the dimensions and tonnage of wagons of the same class; for example, on one of the railways consulted, in the case of covered wagons the capacity varied between 34 and 66 m^3 (1 200 to 2 330 cu. feet), the tonnage between 13 and 20 tons, the tare weight between 7 and 15 tons; in the case of open wagons the capacity of the body varies between 12 and 39 m^3 (425 and 1 400 cu. feet), the load between 10 and 30 tons, the tare between 6 and 14 tons; in the case of flat wagons the surface is from 13 to 40 m^2 (140 to 430 sq. feet), the load 10 to 14 tons and the tare weight 5 to 24 tons.

* * *

As already mentioned, the railways have in mind the standardisation of design. In places where, as in France, several railways exist side by side, a common organisation designs types of wagons known as standardised wagons, which each railway adopts as a rule for its orders. The effect of such a policy will become more marked as time passes.

In Switzerland only two types of frame and the following wagons are now built:

1 special covered wagon of 20 m^2 (215 sq. feet) floor area, 27 m^3 (950 cu. feet) capacity, 15 tons load;

1 ordinary covered wagon of 21.68 m^2 (223 sq. feet), 51 m^3 (1 800 cu. feet), 15 tons;

1 high sided wagon of 21.68 m^2 (223 sq. feet), 20 tons, for coal and coke.

In Belgium the National Company only orders :

— high sided wagons of 25 tons, 18 tons per axle, 30 m^3 (1 060 cu. feet) capacity, 6.98 m. (22 ft. 11 in.) long;

— covered wagons of 20 tons, 47.6 m^3 (1 690 cu. feet);

— bogie platform wagons of 40 tons capacity, of 12.795 m. (42 feet) with low sides or 18.50 m. (60 ft. 8 in.) without sides (and without floor).

— flat wagons of 20 tons capacity with 4 wheels and low sides, 10 m. (32 ft. 9 3/4 in.) long.

In view of the common use of rolling stock, it would be desirable that the uniformity of design of wagons should be the object of a common investigation on behalf of all the railways in order to arrive at international standards.

* * *

The railways do not build wagons for special needs, which would not be of sufficiently general use; they leave to private firms who desire such wagons the task of purchasing them and register them as *private owner wagons*. The private owner wagons are generally considered as increasing the difficulties and costs of operation, and it is considered that recourse should not be made to these wagons except when their utilisation has sufficient advantages to compensate for these drawbacks.

For example, in France the railways allow :

1. wagons meeting special needs of insufficiently general character : beer wagons, ice wagons, wagons for carrying goods requiring special handling or stowing;
2. wagons the use of which requires special precautions : tank wagons, refrigerators.
3. wagons which by reason of their advantages from a technical point of view assist in meeting the competition of other means of transport : wagons of high capacity for coal and coke, self-discharging and tank wagons.

It is interesting to note that the possession of such wagons attaches the client to the railway.

* * *

The uniformity of design of wagons of each class should be completed by *tariff arrangements* of such a kind as would encourage the customer to use the wagons as fully as possible : they would consist for example in making a differentiation between the bases of the rates according to the weight loaded, for example for 5 and 10 tons in Switzerland — 5, 10 and 15 tons in Italy — 5, 10, 15 and 20 tons in Belgium. Undoubtedly the present diversity in the dimensions of wagons does not always make it possible for the railway to draw from these arrangements the whole profit possible; it happens for example that in carrying 15 tons which should profit by the reduced rate for this tonnage it is necessary to supply two 10-ton wagons, or, to carry 20 tons, a 10-ton wagon and a 15-ton wagon or even two 15-ton wagons; in such a case it should be insisted upon that one wagon at least must be fully loaded to prevent certain abuses. This requirement should be maintained even when dispatching loads of 120 tons, 180 tons, 240 tons or full train loads, for which reductions in the rates are granted, under the condition that all the wagons except possibly that which takes the remainder of the load shall be fully loaded.

The application of different rates according to the tonnage would change commercial practices in the sense of increasing the unit used as a basis in such transactions, and favour the introduction of high-capacity wagons, which are economical in use, and which will place the railway in a better position to meet the competition of the waterways.

When the full tonnage of the wagon cannot be used on account of the nature (specific weight) of the goods endeavours are made to take full advantage of the volume, by laying down a minimum rate per square metre, for example in the case of fodder, or by imposing different rates for different loads per square metre.

It does not seem advisable to suggest that the benefits of the lower rates should be subordinated to the use of a given tonnage or length of wagon, as this condition would result in useless empty mileage and difficulties in allocating wagons.

* * *

Now let us consider the *actual allocation* of the wagons *in practice.*

Each station daily establishes, at a given moment, in principle the same moment at all stations, the position in its yards as regards each class of wagon; it thereby makes account of the wagons required according to the demands of the consignors, and of those which are to be used for carrying goods the station itself is responsible for loading (parcels), and on the other hand of the wagons which it has at its disposal to meet these needs; from this, by difference, it calculates the wagons remaining available or those that must be sent to it.

These states are sent to the organisation immediately above, generally by specified passenger train, as they are too long to be telegraphed or telephoned.

The organisation receiving these states links them together and sends the result for the whole of the stations it controls to its superior office, and so on, until headquarters are reached. In order to save time, the lower organisations sometimes telegraph a summary of their position to the higher offices without passing through the intermediate offices; in this case certain stations not taking part otherwise in the allocation, centralise each one of them the information of a group of stations with which they communicate easily by train or by service telephone; in this way the number of summary telegrams to be sent is reduced.

Headquarters allocate between the organisations immediately dependent upon it the extra wagons; in case of shortage, it equalises the available number between these organisations, by taking away from certain of them some of the wagons of which they could have had the use to give them to others less well off. These lower organisations redistribute in their turn or arrange equilibrium between the organisations immediately under them, and so on.

These operations are not all made in turn; the organisation immediately over a group of stations allocates between these stations or among part of them according to requirements, the whole or a part of the excess wagons, while the higher organisations prepare the orders for distribution between the groups which they control.

* * *

Things are not however quite as simple as they appear to be at first sight.

For example, how to arrive at the actual *situation* in a station ?

From one railway to another it is done differently. Supposing it is only a question of ascertaining the position for the next day. It is relatively easy to ascertain the needs by taking into account the demands received and the normal needs of the parcels service; however, it is sometimes necessary to expect additional and varying requests, for example at the ports; but how can the resources, i. e. the wagons available be arrived at,

These are :

a) empty wagons at the station, which can or ought to remain there, waiting for allocation orders.

b) loaded wagons which have arrived, the unloading of which has commenced or not, but which is supposed to be completed during the day;

c) loaded wagons arriving which probably will be off-loaded in time to be used at the station the next day;

d) loaded wagons expected which will possibly be unloaded in time to be used next day;

e) empty wagons on their way to the station through previous orders : too often they are not properly known, the orders not always being carried out with the expected regularity.

This list shows that there is a large element of uncertainty in the position; items *b* and *c* depend upon the periods for unloading allowed, as well as upon the measure in which they are used, a measure which differs from one place to another. In brief, the problem of allocation cannot be written down as an equation; there is an empirical factor which plays its part and which is not taken into account in the same way on all railways.

The methods of allocation differ also by the *hours* at which information is supplied.

There are railways in which the stations prepare their stock position during the morning, for instance between 9 and 11 a. m., the hour being chosen to suit the means by which the state can be sent off, as these ought to be received by the next higher organisations between 12 noon and 1 p. m. This organisation summarises them and communicates its position to the immediately superior office; at the same time it commences to distribute the wagons over its group while awaiting orders from the superior organisation, which are received between 4 and 5 p. m.; at this moment it is possible to transmit the last orders to the stations in the groups. All these orders can be carried out the next day at an early hour or at least in sufficient time.

On other railways, the stations only prepare their states at closing; the groups allocate the wagons during the night or the next day; the central office sometimes only issues its orders the next day during the morning or afternoon. It is obvious that an allocation made in this way is of no use for the wished for day.

However, we must admit these railways obtain satisfactory results, otherwise they would not continue to use a method of this kind.

It should also be noted, as being in the same order of ideas, that if the railways are very spread out, the rapidity with which the orders are carried out must naturally suffer therefrom; no matter at what hour the orders are sent out, it cannot be expected that they will all be carried out the next day.

* * *

If such systems are possible, in our opinion, it is owing to the *relative constancy* of the data on which wagons are allocated, a constancy of which frequently full use is not made.

Undoubtedly many of the railways complete their methods of allocation by organising *permanent currents of empty wagons,* for example of open wagons to the mining districts, or of covered wagons towards the large towns; but the application of this system is not pushed as far as it might be. Again, frequently the stations are forbidden to touch any or part of the available wagons until they receive allocation orders; this appears logical, moreover, as the basis of the calculation would disappear if the wagons it was desired to allocate could be used. But it follows that the wagons remain standing between the moment that the states are prepared and that at which the allocation orders are distributed, and that their turn-round is thus upset.

* * *

As we have already said above, the allocation service of the Belgian National Railway Company has endeavoured to set up a system principally based upon the relative constancy of available stock and requirements over fairly long periods; starting from this, an endeavour has been made to get permanency of the orders as often as possible.

For each class of wagon the scheme is as follows : each station is in posses-

sion of a permanent order for sending away empty wagons not required the second day. The surplus wagons thereby get to certain designated concentration stations without having to await an allocation order and by the first possible train.

These concentration yards have dispatch orders for part of such wagons for the distributing stations, by regular daily train movements; the remainder is despatched also towards distributing stations in regulating currents, the importance and destination of which are fixed by varying orders adapted to suit the variations of the traffic.

The distributing centres feed the using stations in accordance with the requests of these latter, the demands being made at specified moments selected with care and with regard to the possibility of the wagons being sent.

A concentration yard can be at the same time a distributing station as well as a supply station for certain stations or lines; certain currents pass directly to stations where the number of wagons used is large, etc.;

The essential feature in the system is :

1. permanency of the orders to dispatch wagons, i. e. for concentration;

2. the stability of the supply movements, a stability which must be understood in the sense that the wagons are worked forward in these movements in a certain number of trains which are always the same, their number per train being variable according to the number that can be conveyed, but their total number being relatively constant though capable of being altered by allocation orders;

3. the existence of regulating currents to suit the traffic, carefully studied, currents between which the distributor choses, without however being obliged to improvise;

4. the final distribution between the stations by the designated yards selected so as to be able to supply the stations in the direction of the most favourable current of wagons.

The investigation of this plan of allocation is carried out with a view to use the existing trains to the fullest extent, to avoid the running of special trains, and to reduce to a minimum light running and service stops, and to get the wagons as quickly as possible to their destination.

The states supplied by the stations are used in this system to fix the exact volume of the stable currents, as well as the volume and destination of the regulating currents. The distribution between stations is done in three steps : the headquarters fixes the volume of the stable and regulating orders between seven operating divisions; at the headquarters of each of these divisions a distributing office gives similar orders relating to the currents towards the final distributing stations; these distribute between the stations under them. The distributing orders from the central distributors and regional distributors are simple and are sent to a small number of stations; in part they are carried out in advance, just before the orders are received : the wagons never wait for a distributing order to follow their proper course; the demands sent by the using stations to the feeding stations being prepared at the last moment correspond to the real requirements as to number, tonnage, length, etc... of the wagons, taking into account the definite ressources existing in the stations making the demand.

The states to be supplied in view of the distribution on day C by the stations to the superior offices are those of wagons required the second day D according to the requests and those of the available resources, which are the wagons of the system which arrived loaded the previous day B, experience having shown that these wagons are not again used as a rule before day D.

The states are sent to the distributing offices of the divisions by passenger train; a summary of them is sent by each station to a specified yard which sums up these summaries and transmits them by telegraph to the central allocating office, with a copy to the regional distributing office. By means of this copy the divisional distributing offices quickly know the situation in their division, by groups of stations; the central office, so far as it is concerned, draws up the situation of the groups.

At each of the distributing offices, to the demand situations is added a number of wagons equal to the difference between the wagons asked for the previous day (day A) and the wagons actually furnished that day on the groups to which these states relate. This is done to take into account the additional demands sent in after the states are prepared. It is also agreed that the total number of wagons so fixed shall include a number of wagons belonging to other railways equal to that supplied the previous day but one (day A). The divisional offices thus know the needs in wagons belonging to the system in each station distributing them and the central office knows the requirements of each group.

In addition, the wagons of the system which arrived loaded the previous day (day B) forming the resources, to which is added if need be the wagons remaining unused, the distributing offices can calculate the minimum number of wagons to be sent to each distributing station or from division to division and fix the size to be given to the stable and regulating currents mentioned previously. As regards foreign wagons, they are like the others called for by the stations who want to use them, from the stations designated to supply them; these last collect them from passing currents towards their home line, or in the stable currents of foreign wagons which they receive when regular needs justify it.

The stations can, unless ordered to the contrary, take from the dispatching currents and the supply currents but not from distributing currents, that is to say from the final distribution.

We have still to sketch in the method followed in working up the allocation plan. Obviously there is one such plan for each class of stock. A beginning is made by ascertaining for a week of the period to which the plan applies the average number of wagons of the type considered required daily, and the average number of wagons belonging to the railway, received loaded. A diagram based on a map of the system is prepared upon which against the point indicating each station a red square is drawn each square millimetre of which represents the average number of wagons supplied; when this average is equal to or less than 1 it is represented by a red line on the scale of 10 mm. per unit. Wagons received loaded are shown in the same manner, but in blue. By glancing at the diagram the general lines to be given to the stable and regulating currents which go from the regions where blue predominates to the regions where red is the greater are seen at once. In this way also the stations to be selected for concentrating on them the wagons are noticed and the permanent orders for dispatching wagons to the stations are drawn up for the stations concerned. It is now possible to calculate the extent of the concentration, which also includes wagons returning empty from abroad to the exchange points. The yards covering the final distribution between stations are selected taking into account the general directions of the currents and the facilities for working the wagons.

It is then possible to take into consideration the stable and regulating movements. This investigation is made by headquarters, with the assistance, as needed, of the seven regional services (divisions); these latter investigate the despatching and final distribution mo-

vements under the control and with the help of the headquarters service.

In drawing up this plan, care is naturally taken to avoid empty running cross journeys of stock, to utilise to the best advantage available capacity of the trains, to reduce the service stops, etc., preoccupations common to all distributors whatever may be the method of allocation.

* * *

As regards *empty running*, several railways say that the distributing service takes care to send the wagons to the nearest station which has need of them; this principle does not always lead to a solution of the problem.

Let it be (fig. 1) a case of feeding for example stations D and C by stations A and B : at D, $x + z$ wagons are required, and at C, $y + u$; the x and y wagons come from A, the others from B. The empty run $bx + cz + du + ay = (b\text{-}a)\ x + (c\text{-}d)\ z + a\,\mathrm{A} + d\,\mathrm{B}$ (A and B being the number of wagons to send respectively from A and B).

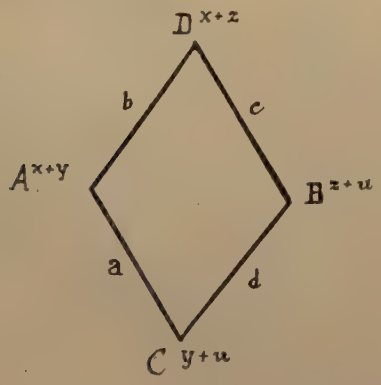


Fig. 1.

If $b\text{-}a$ is less than $c\text{-}d$ there is every reason to feed D from A in preference and C from B. The wagons from A will then go to station D; example : a = 15 km., b = 20 km., C = 18 km., d = 11 km. If d becomes 14 km. instead of 11, then $b\text{-}a$ becomes greater than $c\text{-}d$ and it will now be necessary to feed D from B and C from A.

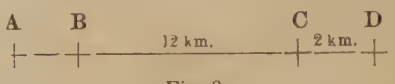


Fig. 2.

Another case where the principle is at fault is the following : stations A, B, D (fig. 2) have usually too much stock, and dispatch it in the direction of A towards D; station C, short of stock, obviously ought not to be fed by D, 2 km. away, but by B, although B is 12 km. away.

Finally, when the empty wagons run partly over a common line the choice of the stations to feed them becomes indifferent from the point of view of empty running. In the case of figure 2 it does not matter whether C is fed by B or by A.

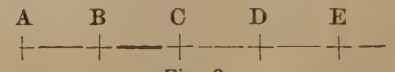


Fig. 3.

Let us notice again the case of several stations situated as sohwn in fig. 3 in which E can be fed by D, D by C, C by B, B by A, while E alone has need of wagons and A alone has an excess of wagons, without increasing the empty running; this is sometimes a method of accelerating the turn-round of the wagons, so that on a system developed lengthwise all the wagons will move short distances outside the hours of loading and all the stations will have their wagons in time, whereas if they were sent from A direct to E, it may occur that E is not supplied with wagons quickly enough.

The reduction of empty running to a minimum is only possible as the result of a close investigation, and the same applies to the reduction of service stops with the costly shunting and loss of

time involved, as well as the indication of the most favourable trains. Improvised methods should therefore be avoided as much as possible in the *arrangements made by the distributors*, and this condition is realised, in the methods described, in a very different extent from one system to another, even to the point that one railway expresses the opinion that it does not believe in the elaboration of distributing orders according to fixed rules, that this elaboration depends upon the professional knowledge of the men « and upon their sense of what is suitable to devise the most advantageous combinations ».

In Belgium 95 % of the empty wagons moving work according to fixed rules; another railway reports 80 %, etc...

* * *

When with constant turn-round the traffic is constant, there is equilibrium between supplies and demands.

When the traffic falls off, this equilibrium is broken, and it becomes necessary to *stable wagons* and inversely, when the traffic picks up the wagons have to be put back into traffic. The most rational method of acting consists, it appears, in the event of the traffic falling, to continue to supply normally, which is equivalent to momentarily supplying in excess the using stations, which so find themselves with stock in advance; this excess rolling stock reduces by the same amount the rolling stock out on the line, which is thus brought automatically into harmony with the new requirements. In other terms, the number of loaded wagons falling, the same thing occurs with those arriving loaded at their destination; after unloading, those of these wagons not reloaded at the station feed the movement towards the concentration yard and the distribution and supply movements; as they have become less numerous, the volume of these movements is automatically reduced to the level of the requirements. If further falls in traffic occur, the using stations are again over-supplied and end by becoming full; then orders are given to certain stations to hold after unloading wagons coming to them loaded. During serious crises, in the end it becomes necessary to send the wagons to holding sidings, wherever there is place, but then it is no longer possible to avoid useless empty running, a condition realised as soon as wagons can only be held at the consuming stations or at the stations at which the wagons arrived under load.

Many railways stable in holding sidings each year part of their stock during a fairly long period. It is desirable in this case to systematically withdraw from circulation worn wagons and in general those of which the maintenance costs are high :

When the traffic increases again, first of all the wagons in sidings at using stations are returned into traffic the volume of the ordinary supply movements increases after a few days and the available number of wagons in use ends by corresponding with the new position; if the traffic still further increases the same procedure takes place, the number of trains increases, and the wagons held in the receiving stations can gradually be worked in to the despatching movements, etc...

* * *

It may be remarked in passing that stabling wagons in holding sidings or removing them therefrom can be made necessary also by altering the turn-round period of the wagons; an appreciable increase in this period usually denotes some difficulty in the train workings and illustrates the utility of closely watching variations in the turn-round period.

It may be of value to possess a number of wagons greater than that strictly required if supplementary light running can be allowed, as well as an increase of

trains and of shunting at service stops in order to increase the turn-round. A balance sheet has to be got out : the capital and sinking fund charges due to the increased number should be compared with the saving in operating costs resulting from the empty wagon mileage avoided as a result of this increase. A *supplement of stock* makes it possible to form a reserve in the regions or stations at which the traffic undergoes sudden variations; this is the case in particular at the ports; in this way movements of rolling stock which could be used shortly where they are and which would have to be replaced are avoided. A theoretical example will show the point : let us suppose two ports, P1 and P2, 100 km. apart; on even days there is an excess of 60 wagons at P1 which are required however on the odd days; at P2 the same excess of 60 wagons is found the odd days and they are required the even days. It would be possible to organise a direct train on the even days between P1 and P2 and on the odd days from P2 to P1 : thus every day there would be a gain of 60 wagon-days, i. e. a stock of 60 wagons, but the 6 000 empty wagon-kilometres worked daily would be lost.

By leaving the wagons in situ these 6 000 wagon-kilometres are saved but at the cost of an increase in the stock of 60 wagons; this last cost is lower however than the cost of the empty running. On the Belgian National Railway Company the stock of wagons is calculated so as to meet the average traffic in seasonal periods of heavy traffic, by the formula : stock = wagons to be supplied $\times$ by the turn-round normally realised during these periods. An excess of 2 % approximately is added thereto as a « manœuvring mass », having regard to the considerations which have just been developed.

Other railways proceed in a similar manner and increase their stock to the value of the average needs of normal periods of heavy traffic; certain, however, consider it sufficient that the stock should meet the average needs of the year. The rule to adopt depends evidently on the legal obligations of the railway as regards the supply of wagons, and also upon the extent of the fluctuations in traffic during the year.

According to the basis allowed when deciding the stock required, a *shortage* of stock will occur at certain seasons, either regularly or only when the peaks are abnormally high. Then special measures become necessary.

On the Belgian National Railway Company, the state of needs B and resources R are prepared in the ordinary way, and the ratio $\frac{R}{B}$ is calculated therefrom. The needs of each consignor are reduced straight away in this ratio, and the allocation is made on this new basis.

Naturally all the distributing centres down to the stations are informed of the percentage thus calculated.

But certain consignors, such as collieries, quarries, etc., then show a tendency to exaggerate their demands. To meet this manœuvre the stations instead of keeping to the demands made estimate the needs of these clients from :

1. the average loadings prior to the shortage;

2. the rate of loading at the corresponding period in previous years;

3. the tonnage extracted;

4. the importance of the variations in the stock;

5. the possibilities of use being made of competing means of transport.

The same procedure is applied should the case arise to determine the needs of each station.

Similar expedients are applied by most railways. In this way the consignors are offered wagons of other kinds than those demanded, when shortage either does not

exist or is less serious in such classes of wagon.

Priority is accorded if need be in the event of shortage of stock, to certain classes of traffic, for example foodstuffs, coal, etc..., ports, industries with constant traffic (quarries, mines).

As a preventive measure, an endeavour is made to persuade the public to profit as far as possible from the calm periods preceding the seasonal rushes and to send away their traffic in advance; in particular this point is stressed with the public administrations and the army. Furthermore arrangements are made for the lifting and greasing of the wagons to take place outside the period of heavy traffic.

Finally the railways have recourse in larger measure than usual to the use of other companies' rolling stock.

III. — Distribution of sheets, binding chains, ropes, etc.

The distribution of sheets, chains, etc., is done on the same principle as that of wagons; care is taken to supply these accessories at the same time as the wagons with which they are needed.

All railways do not possess their own sheets; some prefer to rent them from suppliers with whom they have a contract; a mixed system is also applied : the railway's own stock of sheets is limited so as to be always in use and any others required are obtained by hire.

IV. — Checking the way the allocation orders are carried out.

In order to control the carrying out of allocation orders the stations should as a rule report daily the number of empty wagons that they have despatched, indicating the destinations and the trains used; they sould in the same way report the number of wagons received. These informations are given on the *daily state* of available wagons and requirements.

The stations also indicate on these states the number of wagons supplied and those not sent, those still lacking in spite of a first reminder, a second reminder, etc.... finally the number of wagons in holding sidings, i. e. that have remained unused during a given time varying from one railway to another.

These various data make it possible for the distributing organisations to check if the distribution is being done *equitably* between the stations, if the despatch of wagons covered by a distribution order has taken place under conditions of *sufficient speed,* using the *most suitable trains, etc...* and if the data supplied in view of the distribution is exact.

This control is only done as a rule by surprise checks, except the inquiry into wagons not supplied in time, which moreover is easy.

To this *control* carried out by the *offices* there is added on many railways a *travelling* control : inspectors check on the spot during surprise visits if the stations are preparing conscienciously the daily states to be supplied to the distributing organisations and if they give to the distribution orders received the desired sequence under the best conditions.

In time of shortage of stock certain railways require the stations to supply each day details concerning the wagons loaded by important and regular customers, e. g. collieries. The distribution organisation immediately over the stations checks if these clients are treated equitably in regard to the average percentage of the demands met by the railway; it intervenes to put right as far as possible any defect.

The central distribution organisation receives a similar state, not daily but weekly, and controls the action taken by the organisation immediately under it.

* * *

The checks mentioned only take place *after the event.*

In a system of allocation based upon the permanent order being predominant, it is possible to follow the working of the system so as to be able to interfere to *prevent trouble* arising.

Thus on the Belgian National Railway Company whose method has been sketched in above, each concentration station sends to the central distributing office towards 7 a. m. and 3 p. m. a telegramme indicating, by train and destination, the number of empty wagons despatched; the first telegramme gives these particulars for the period from 2 p. m. (the day before) to 6 a. m.; the second for the period from 6 a. m. to 2 p. m.; these telegrammes also indicate the number of wagons received for concentration during the same period and the number of empty wagons standing in the station at the moment the telegram is handed in. The regional (divisional) distributing offices receive copies of the telegrammes from the stations in their division.

When the central allocating office (the B. C. R.) sees that an expected movement is not of the expected volume, it immediately looks for the reasons in collaboration with the regional distributing office (the B. R) concerned, and carries out the alterations required to make good the deficit or, if there is a shortage, to re-establish equilibrium.

The stations should moreover advise by telegramme their regional distributing office when the empty stock which they have need of has not come by the train laid down in the instructions regulating the final allocation, i. e. the distribution between the stations by the designated distributing yards. Thus warned, the distributing offices take all possible steps.

Of course, checks « after the event » remain necessary; thus for example, every day the B. C. R. makes a check to see if the empty wagons sent by one division towards the others, agree with the possible movements as revealed by the statistical data of the positions; if the agreement is not sufficiently close the statistics are incorrect. The divisional offices which should carry out a similar examination for their stations grouped into a few districts for convenience's sake, to facilitate it, are then called upon for explanations : the group or groups of stations where the errors occur are separated and in these groups the stations in fault are brought to book. It should be noticed that these errors are frequently deliberate when there is a shortage of material, the stations then having a tendency to put themselves into a comfortable position, just as do the groups in which the rolling stock is as a rule more than sufficient for requirements.

The use made of the capacity of the wagons is not generally checked except by surprise checks, by travelling inspectors, who compare for this purpose the indications given by the register of demands and those of the waybills.

B. — Investigation into the turn-round of the rolling stock.

I. — Definition and methods of calculation.

The turn-round period of the rolling stock, *i. e.* the duration of its movement or the time that elapses between two successive loadings of a given wagon, is useful information, principally in order to determine the stock required for a given traffic, of which the financial charges and others form an important factor in the cost price of transport.

The turn-round multiplied by the number of wagons to be supplied daily is the number of wagons in good condition to be put into traffic.

The variation of the turn-round gives moreover valuable indications as to the way in which the allocation service is carried out, upon the proper running of

the trains and upon the characteristic modifications of the traffic.

The significance of the turn-round period and its variations depend evidently upon the *formula* according to which it is calculated.

Unfortunately no uniformity is realised in this respect and the turn-round periods calculated by the different railways cannot be compared.

If we indicate by F the daily average supplied of a given class of wagon during a selected period, and by E the corresponding stock of these wagons, the turn-round r is evidently given by the equation $r = \frac{E}{F}$.

But if E represents the total stock, including wagons out of service through damage and wagons held in sidings, unused owing to excess of wagons, the turn-round depends not only upon the quality of the allocation, on the more or less great regularity of running of the trains, on the distribution of traffic by class of goods, by origin and destination, but also on the speed with which repairs are carried out, upon the number of damages, especially those occurring during shunting, and the total amount of the traffic. If, on the contrary, E is the stock really used the turn-round as calculated is only a function of the three first factors. From these the last is still to a certain extent outside the control of the management, especially as regards wagons sent abroad, the turn-round of which depends upon the neighbouring railway systems. If we again take away from E the average stock of wagons considered as being off the system, we get the turn-round period on home service only, which alone makes it possible to appreciate the working of the distribution services and of the trains, the analysis in this case being greatly simplified.

* * *

Having said this, some of the formulæ in use may be given :

France.

E = the daily number of wagons on the system (including foreign owners);
C = wagons loaded;
E_c = wagons received loaded from neighbouring systems;
S_c = wagons dispatched loaded from the system;
r = the turn-round period;

I. — Formula used on the *Paris-Orleans Ry.*: $r = \frac{E}{c}$.

II. — Do. *Midi Ry.* : $r = \frac{E}{C + E_c - S_c}$.

III. — Do. *Est Ry.* : $r = \frac{E}{\frac{C + E_c - S_c}{2}}$.

IV. — Do. *Alsace-Lorraine Rys.* and *Paris-Lyons-Mediterranean Ry* :

$$r = \frac{E}{C + E_c}.$$

V. — Do. *Nord* and *State* Rys.:

$$r = \frac{E}{C - S_c + \frac{3}{4}(E_c + S_c)}.$$

The turn-round period is calculated per week of seven days on the Paris-Lyons-Mediterranean and by month on the Paris-Orleans.

It should be noticed that if $E_c = S_c$ tends towards 0, i. e. if the number of the number of the loaded wagons despatched is very close to the number of loaded wagons received, the formulæ (I), (II) and (III) are equivalent to one another.

As a general rule, E only includes wagons in good condition.

However the Midi and the Alsace-Lorraine use a second turn-round formula which also includes in E the number of wagons stopped for repairs.

No adjustment in E is made to take

into account wagons not used by the allocation, i. e. « excess » but the railways which systematically stable wagons and take them out of traffic for a more or less long period as a result of fall off of traffic subtract them from the number E.

The Alsace and Lorraine Railways use a third formula representing the turn-round under the form

$$\frac{E}{C + E_c + S_v}$$

in which S_v represents foreign wagons returned home empty.

It will be seen from an examination of the formulæ that the railways take account in a different manner of the effect of wagons received loaded and despatched loaded in traffic with neigbouring systems. This difference explains itself it would appear by the conditions particular to each railway, upon which conditions the replies give no information.

Italy.

State Railways.

The turn-round is calculated by month, half year or year.

The numerator is the number of Italian and foreign wagons present on the system, less damaged wagons under repair or waiting for repair, wagons set aside for service purposes, and excess wagons or those not used for other reasons. The wagons are considered as being in excess when, empty at 5 p. m., they are not required for the next day.

The denominator represents the daily average of wagons loaded including loaded wagons received from other railways.

Belgium.

National Railway Company.

The turn-round period is calculated by week.

Foreign wagons are not included in the numerator nor in the denominator.

The formula used is $r = \frac{E - A - G}{F}$

in which E is the total stock of wagons in commercial service belonging to the railway itself, not including wagons on hire nor those taken out of commercial service for any other reason :

A = the average number of wagons of the system, stopped for damage;

G = average number of wagons of the system, unusable by the distribution service, as being in excess. Wagons remaining empty for two days on end about 6 a. m. in a given station, without having been covered by a distribution order are considered as in excess;

F = the daily average of the supply of wagons belonging to the stock of the railway, i. e. the supply for the week divided by the number of working days included in it.

The turn-round period so calculated is called « turn-round in all services taken together » *i. e.* turn-round of the wagons used indifferently in home service or as between railways.

It is used notably for deciding the required stock.

The turn-round period in home service only is also calculated.

The hypothesis is made that a wagon loaded for abroad has a turn-round equal to that of a loaded wagon for a destination on the system increased by the time it is off the system.

The turn-round in home service then is calculated by the formula

$$r = \frac{E - A - G - M}{F}$$

in which M is the mean daily number of wagons away from the railway during the period considered; the meaning of the other letters is the same as in the first formula.

The turn-round in home service is the index of the proper working of the distribution and train services.

In these formulæ, the effect of foreign wagons is completely eliminated.

The turn-round is calculated for the wagons as a whole, except on the Belgian National Railway Company where it is calculated by class of wagons (covered, open, short flat, bogie flat).

Finally, the rotation of the wagons used in interchange traffic is calculated separately. To get this a calculation is made each week of the number N of the wagons off the system; at the same time the number S of wagons sent away and the number R of wagons returned is noted; the total of the N is the number of wagon-days abroad. By dividing ΣN at first by ΣS, then by ΣR we get two numbers of days between which is the average time that a wagon remains away; this period is taken as being $\frac{\Sigma N}{\frac{\Sigma S + \Sigma R}{2}}$, a number intermediate between the two limits.

The turn-round period of a wagon sent abroad is therefore $r_i + \frac{\Sigma N}{\frac{\Sigma S + \Sigma R}{2}}$

r_i being the turn-round in home service.

II. — Separation of the elements included in the turn-round.

The Belgian National Railway Company is also the only one of the railway companies considered in this report which carries out continuously a *systematic investigation* into the elements of the turn-round : time taken to work the wagon forward, time passed for service purposes in the marshalling yards.

It appears to us therefore interesting to give particulars of the method used.

The turn-round in home service is divided up into :

1. the time spent « in position » i.e. on the sidings of the goods yards, on private sidings, etc...; it includes the time taken to load and unload properly speaking and that which precedes and follows these operations;

2. time passed waiting for marshalling by wagons intended to be « placed » or coming therefrom. This time is only calculated for stations connected with a marshalling yard;

3. time passed in stops at intermediate stations, between the departure and destination stations;

4. time passed on the journey.

* * *

The stations calculate for the wagons of the railway proper used and for foreign wagons the number of hours lost in the stations according to a method based on the following reasoning :

If during a day all the wagons leaving the station after having been there were received or had been present at 0 a. m. (midnight) the number of hours that they would have passed altogether would be Σnh, n being, for a given train leaving, the number of wagons taken away, h the hour this train left. If there remain s wagons at 12 p. m. (midnight the following day), it is necessary to add for these wagons $24 \times s$ hours.

But as all these wagons that left or are still present at 12 p. m. were not present at 0 a. m., but in part entered during the day; it is necessary to subtract from the wagon-hours calculated above $\Sigma\, n'\, h'$, n' being the number of wagons taken into the station to stand there or to be shunted there by a given train that arrived a time h'.

It may be remarked in passing that by dividing the number of wagon-hours calculated as above by the number of wagons which came in Σn or the number of wagons which left $\Sigma n'$ we get the two limits between which lies the average time the wagon spent in the station; if these two limits are close together we can take one of them or better half their sum, or again the result obtained from $\frac{\Sigma n + \Sigma n'}{2}$ as the average time spent in the station.

* * *

By the method described above, the stations calculate :

a) the hours lost in the stations, for marshalling and in position,

b) the hours lost in position only,

c) the difference between *a*) and *b*) gives the hours lost in the marshalling alone.

The stations not adjacent to a marshalling yard evidently cannot make any distinction between *a*) and *b*); *c*) is the same as *a*) and *b*). Each week, the central distributing office (B. C. R.) receives information about the number of hours lost in position and in the marshalling yard through the divisional offices which totalise them for their division and which receive themselves information through stations indicated, which totalise the numbers for a certain given number of stations.

The B. C. R. carries out the following operations :

I. — *Hours « in position »*. — These affect the wagons used, belonging to the railway and foreign wagons received loaded.

The following particulars are prepared in turn :

a) the number of operations (loading or unloading);

b) average standing time per operation;

c) the number of hours lost by the company's own wagons used;

d) the time « in position » per turn-round period of a company's wagon;

As regards *a*) 1. Number of operations for the wagons belonging to the railway : there are two operations per supply, except in the case of

— the wagons returning empty from abroad : there is no unloading;

— wagons supplied under agreement to foreign railways for interchange traffic : there is no loading.

If F is the number of wagons of the railway put in position for loading (supply) :

V the number of wagons returned empty from abroad,

B the number of wagons supplied by agreement to neighbouring railways, the number of operations is 2F — (V + B).

2. The number of operations for foreign wagons :

There is one operation per foreign wagon received loaded and one operation per foreign wagon despatched loaded.

If C is the number of foreign wagons received loaded and D that sent away loaded the number of operations is C + D.

3. Total number of operations for the whole of the wagons, those belonging to the system and to others systems. It is 2 F — (V + B) + (C + D).

For *b*) : The average period of an operation is :

$$b = \frac{L}{2F - (V + B) + (C + D)}$$

L being the number of hours lost when « in position ».

For *c*) the number of hours lost « in position » by wagons belonging to the system is : $L = b\ [2F - (V + B)]$.

For *d*) the time « in position » per period of turn-round of a wagon of the system is $\frac{L}{F}$.

II. — This element being known, the calculation of the hours passed per turn-round period in the marshalling yards, *i. e.* in service stops, is next considered.

The following are culculated in turn :

a) the average time of a service stop;

b) the number of service stops per turn-round of a wagon belonging to the system;

c) the time waiting in the intermediate marshalling yards per turn-round;

d) the time spent waiting in marshalling yards adjacent to the local stations per turn-round.

For *a*): the hours lost E in a marshalling yard affect :

the wagons in transit, in number t,

the wagons for placing « in position », in number p,

the wagons coming from the public sidings, in number q.

Then if x be the mean time of a service stop of a wagon in transit,

x' the mean time between the arrival of a wagon in the station and its being placed « in position »,

x'' the average time between withdrawing from position until the wagon leaves the marshalling yard.

We get $E = tx + px' + qx'' =$

$$x\left(t + p\frac{x'}{x} + q\frac{x''}{x}\right)$$

For a normal period the real waiting time of a transit wagon i, the average real period j of a wagon before being placed « in position », the average period k for a wagon returning from being in position, are obtained it being agreed to take $\frac{x'}{x} = \frac{j}{i}$ and $\frac{x''}{x} = \frac{k}{i}$.

We then have

$$E = x\left(t + p\frac{j}{i} + q\frac{k}{i}\right)$$

and

$$x = \frac{E}{t + p\frac{j}{i} + q\frac{k}{i}}.$$

Each station gets out the number $t + p\frac{j}{i} + q\frac{k}{i}$ concerning it; by dividing by the sum of these numbers $t + p\frac{j}{i} + q\frac{k}{i}$, the value of E for the whole of the marshalling yards of the system, we get the average period x for a service stop for the whole system.

For *b*) : the total of the service stops is formed of the service stops of wagons belonging to the railway system itself and of those of foreign wagons. The hypothesis is made that the number of service stops and their total duration for each of these classes are proportional, in the case of the first, to the turn-round in home service and, for the second, to the time they are on the system : this period is, in the case of foreign wagons, roughly equal to 9/10 of the turn-round period in home service of the wagons belonging to the railway.

If F be the number of company wagons supplied during the period considered (a week) and R the number of foreign wagons returned home, t being the total number of service stops on the system (the sum of the t 's of all the stations) we have $a : g = \frac{t}{F + 0.9R}$ as the number of service stops per turn-round-period of a wagon belonging to the system.

For *c*) : Finally, the period in the intermediate marshalling yards is per turn-round : $e = gx$.

For *d*): The difference $E - tx$ represents the hours lost waiting in the terminal marshalling yards, both for the wagons of the system and for foreign wagons. The details are separated out as when calculating the time spent « in position », by allowing for each loading or unloading operation an equal time, prior to and after marshalling, *i. e.*

$$u = \frac{E - tx}{2F - (V + B) + C + D}.$$

For the wagons belonging to the system as a whole, we have therefore as hours lost under this heading $U = u\,[2F - (V + B)]$ and consequently the time spent waiting in the marshalling yards adjoining the station at which the wagons are used is per turn-round : $f = \frac{U}{F}$.

III. — There remains to be calculated the time taken travelling.

Knowing the turn-round in home service, *r* and by turn-round : the time spent « in position » *l*,

the time passed waiting in the terminal marshalling yards, *f*,

the time passed in intermediate service stops, *e*, we get, for the time spent in running, per turn-round,

$$a = r - (l + f + e).$$

* * *

The investigation given above is made weekly.

It makes it possible to bring out certain general causes which diminish the efficiency of the rolling stock and thereby gives the management information as to the opportunity of taking special steps and the nature these should assume.

III. — Methods for reducing the period of turn-round.

The railways endeavour *to reduce the turn-round period* of the rolling stock not only when stock in short but at all times; naturally, when there is plenty of rolling stock available, the supervision exercised on the turn-round is especially with the object of avoiding the initiation of objectionable practices that it would not be possible to suppress when the traffic is heavy, and in addition the chief object looked for is the reduction of costs to the minimum. Consequently, when plenty of wagons are available, the journey time and the time spent in service stops are sacrificed so as to assure that the trains are made up to as full load as possible, that the marshalling yards use the fewest possible shunting engines, and that empty running is via the shortest route.

* * *

In times of shortage of stock, on the contrary, the shunting engines are used more freely with the object of emptying more quickly the reception sidings and of forming more frequent trains. The empty wagons are sent, if need be, by a longer route, if this is quicker.

* * *

An endeavour is made always to run, as far as possible, direct trains, avoiding service stops, or trains with through rakes, i. e. passing directly from one train to another, at the shunting yard at which connection is made, and thereby not making more than one service stop of short duration.

* * *

The speed of the trains is not without importance : undoubtedly if we appreciate that the wagons only run about 40 km. per day the saving of direct time that a greater speed can give is little but the indirect gains are considerable, notably by giving better connections between trains, in holding sidings or passing loops suppressed or more carefully directed, etc...

* * *

In this case the intelligent intervention of the regulating offices or of the dispatching service can often avoid serious losses; it is a good thing for these centres to be authorised to make goods trains run as much in advance of their normal bookings as possible.

* * *

The continuous brake is again an element which favours the reduction of the journey time.

* * *

Besides the steps taken in connection with the organisation of trains, in times of shortage of stock, it is also prescribed that empty wagons shall be given priority in working over loaded wagons

with certain specified exceptions. Such an instruction is justified

— firstly by psychological reasons, as it is known that the stations supervise more closely the working of loaded wagons;

— secondly because the customers themselves take care to call the attention of the railway to delays to loaded wagons.

When the traffic is at the normal level, attention is given rather, as has been said above, to using the trains to their full capacity and some tolerances are allowed, especially as regards the volume of permanent orders : it is of little importance if the currents should be sometimes slightly heavier than laid down or slightly lighter, for the using stations have wagons standing in their sidings, from which profit is made either, let it be said, in passing, to grant facilities to the customers by supplying at once the wagons asked for, or by supplying them in anticipation, e. g. the day before that of loading.

* * *

It should be noted also that the working of parcels wagons is carried out on certain railways usually by goods trains under the same conditions as full-load wagons and on others a definite separation is made between trains allotted to these two classes of service.

* * *

On several railways the rates provide for reductions for certain goods sent in complete train loads, so formed as not to undergo any shunting en route : service stops are avoided in this way.

Furthermore the application of lower rates is sometimes subordinated to a reduction of the normal loading and unloading periods; consequently to a reduction in the period the rolling stock stays in the loading or unloading stations.

* * *

To reduce this period, another important factor in the turn-round, the period of *loading and unloading* is limited by requiring standing charges if the periods fixed by the rates are exceeded.

There periods vary considerably :

In France, the loading or unloading of the wagons should be completed during the day in which the wagons have been put at the disposal of the consignor or the consignee, provided that the advice note was sent to the people concerned so as to get to them the previous day before 6 p. m. and that the wagons be at their disposal at the regular hour of opening of the station. If one or the other of these conditions is not fulfilled the time allowed is increased by 24 hours. In the case of successive operations of unloading followed by loading the times allowed are those granted for each of these operations.

These periods are reduced in the case of private sidings and at the ports, within the limits determined by the tariffs.

In *Switzerland* the time allowed is 24 hours for each loading or unloading operation; the hours are counted between midnight and midnight.

In *Italy* the time allowed is also 24 hours except for certain goods; it is counted from the hour the advice note that the wagon has been put at disposal, is sent. When this advice is sent by post the time is increased by 36 hours and does not begin until the hour of midday or midnight following the hour the advice note was posted.

In *Belgium* the period is 8 hours per operation; it begins from the time the advice note that the wagon is available has been sent; the hours between 7 a. m. and 7 p. m. in winter, 6 a. m. and 7 p. m. in summer only are counted; these periods are for operations carried out in the station yards.

For private sidings the period is reduced to 6 hours, but only the hours within the period 7 a. m. to 4 p. m. are taken into account.

* * *

When these periods are exceeded, standing charges are applied; these charges are calculated either by the hour (every hour standing being taken into account, those of the day as of the night), or by each period of 24 hours commenced.

The rates are uniform of more usually, progressive.

The average number of wagons standing beyond the times fixed varies naturally with the length of these allowed periods; thus, for example, it is 1% of the stock in Switzerland, where the time allowed is 24 hours, and 3 % in Belgium where the time is 8 hours.

When stock is short, the rates of standing charges are sometimes increased or the times allowed for loading and unloading are reduced. Some railways have a scale of standing charges for the periods of ligth traffic and another scale for that of heavy traffic.

It is not usual to allow any premium to the consignors or to the consignees when the loading or unloading is carried out more quickly than the time allowed.

* * *

Besides the delays allowed by the regulations to customers, the time lost between the arrival of a wagon and putting it at the customer's disposal, whether consignor or consignee, must be taken into consideration.

In order to reduce this time, the advice notes of arrival are sent quickly by special messenger, by telephone of telegraph or by express letter, the post is only used when no quicker method is available or when the time to be gained in practice by using the methods is nil or insufficient to cover the additional cost.

Several railways organise the sending out of the advice notes in such a way as to get them to the interested parties before the wagons arrive at the station; this station is notified by the preceding marshalling yard, and sends these advice notes as soon as it is certain to be able to put these wagons in place at the hour stated on the advice note.

* * *

The stations also take care to avoid loss of time between the loading and unloading and the departure of the wagon. Their attention in this field is supervised and especially in times of shortage of wagons, any irregularities committed are strongly punished.

If necessary certain stations are authorised to run special through trains each time the number of wagons to be worked forward justifies this measure.

Summary.

A. — Organisation of the allocation of rolling stock.

When organising the allocation of rolling stock both the interest of the public and the interest of the railway should be equally taken into account.

As regards the public interest, demands should be met punctually, within the shortest possible time.

As regards the railway interest, the distribution should make certain that the rolling stock is supplied with the minimum of expense, i. e. with a minimum stock, with a minimum of empty running, service stops and shunting during the journey.

When these interests conflict they must be made to harmonise by reasonable regulations.

In consequence, the following principles are applicable :

1. An endeavour should be made not

to make full use of the legal time allowed for supplying the rolling stock, but to reduce the times in practice to a minimum.

2. The right of selecting the stock to be supplied remains with the railway within the limits of the tariff conditions.

The number of types of wagon in the stock of the railway is reduced to a minimum and each class is made uniform, tending towards the maximum tonnage capacity consistent with the maximum axle load allowed.

4. Wagons which are not used sufficiently generally are not introduced into the stock of the company, but permission to register special wagons belonging to them and reserved for their own use is granted to private owners.

5. The full use of the capacity of the wagons is favoured by suitable arrangements of rates.

6. Traffic in large loads or by full trains is favoured by suitable rates measures.

7. The benefit of a reduced rate should not be subordinated to the supply by the railway company of wagons of a definite type.

8. All endeavours are made to speed up as much as possible the operations in connection with the allocation of wagons, namely. by fixing convenient hours for the supply of the necessary information to the allocation offices and by the dispatch of the distribution orders, and by dividing the work of distribution between several organisations or stages.

Particularly valuable advantage can be taken, when distributing wagons, of the relative constancy of the demand and the available supplies, each time that this occurs. This constancy makes it possible to elaborate a distribution scheme including in addition to the permanent orders which predominate, variable orders prepared in advance, so as to avoid improvising.

When such a plan is possible a wagon never stands as the result of there being no distribution order.

10. The train service should be organised so as to assure the wagons being sent forward as rapidly and as directly as possible, avoiding shunting and loss of time in service stops. The timetable should assure that the stations are served at convenient hours for putting the wagons at the disposal of the interested parties and their removal without loss of time.

11. In the event of there being a superabundance of wagons, the excess wagons should be as far as possible placed in holding sidings in the stations where the despatches are in the majority, and only subsequently in the stations where the number of wagons received predominate. When removing the wagons from such holding sidings, those wagons at the stations from which despatches predominate are first of all put into circulation, and later those stabled at stations chiefly *receiving* loaded wagons. This method harmonises with the alterations which naturally take place in the train working, both when the traffic falls and when it increases.

When part of the wagon stock can be held in holding sidings each year during a fairly long period, it is advisable to withdraw from circulation the wagons which are most subject to damage and the out of date wagons.

12. When there is a shortage of rolling stock, an endeavour is made to distribute the rolling stock as equitably as possible between the consignors taking into account their normal requirements and the importance of the consequences of delay in supplying the wagons.

B. — Investigation into the turn-round of wagons.

The determination of the turn-round period makes it possible to fix the number the stock of wagons should reach

and the investigation of its variations gives indications as to the way the services are working and the characteristic alterations in the traffic.

The period is calculated according to formulæ, and at intervals which differ from one railway to another, and most frequently for the total stock of wagons only, although it is useful to know it by classes of wagon; elements included in the turn-round are only too often not separated out, or at least not systematically nor continuously.

Under these conditions, no information can be drawn from a comparison of the turn-round period of the different railways and the indication supplied by the variation of the turn-round period on a given railway are illusory.

In conclusion it would be desirable to see a single method of calculation adopted for this statistical element.

All railways take steps to speed up the turn-round period of the rolling stock, especially when there is a shortage of stock, it being understood that when wagons are in excess the chief thing looked for is economy.

The exceptional steps taken in times of wagon shortage are chiefly :

1. the increase in shunting facilities at the service stations;

2. formation of more frequent trains even at the expense of the best use of the loads allowed;

3. working of empty wagons by the fastest route, even if longer;

4. working empty wagons forward in priority.

[625. 162 & 656. 254]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION I :

The protection of level crossings in view of modern developments in road traffic.

REPORT No. 3

(All countries except America, Great Britain, Dominions and Colonies, China, Japan, Egypt, Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxembourg, Norway, Sweden and Switzerland),

by A. MISZKE,

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The questionnaire sent out to the various countries covered by our report included three groups of questions : I. Laws and agreements relative to the supervision of level crossings; II. Statistics; III. Methods of protection of the traffic at level crossings.

CHAPTER I.

Laws and agreements.

Question 1. — *What are the laws or legislative regulations which control level crossings, in particular what are the modifications of these introduced in recent times by reason of the modern development of automobile road transport?*

Question 2. — *Are there in existence administrative rules of the same kind?*

The question of level crossings from the point of view of the withdrawal of supervision has been discussed at the London Congress. Since, out of all the countries comprised in the present report, Czechoslovakia alone had replied to the questionnaire of Mr. Maas-Geesteranus, I wish to describe, in the replies received, not only the progress which has been made since the London Congress, but also to present the actual state of the question studied.

The legislative regulations and the administrative rules of Germany, Poland, Czechoslovakia and Jugoslavia shew that of late, these States take into account the influence of the development of automobile road transport on the method of level crossing protection.

In Germany, the rules relating to level crossings are to be found in:

1. *Eisenbahn-Bau und Betriebsordnung* — E. B. B. O. — (Rules for the construction and operation of railways);

2. *Technische Vereinbarungen über den Bau und den Betrieb der Hauptbahnen und Nebenbahnen* (Technical prescriptions for the construction and operation of main and secondary lines) and

3. *Grundzüge für den Bau und den Betrieb der Lokalbahnen* (Principles for

the construction and operation of local lines).

The last edition of *Bau und Betriebsordnung* of the 11 July, 1928, (legal regulation put into force on the 1 October, 1928) recommends crosses as warning signals instead of boards as previously used.

In Poland there are now in force : *Leading requirements for the construction and operation of public railways of standard gauge,* ratified on the 2nd December 1931.

Recently a special commission has elaborated regulations for the protection of level crossings, taking into consideration the exigencies of modern automobile traffic, which tend to limit supervision and to replace it, according to visibility, by indicating posts or automatic optical signals.

These regulations have already been ratified at the beginning of the year 1932, and details of them are given under the specific headings. The regulations of the International Railway Union (U.I.C.) must be applied during the course of two years.

In Czechoslovakia changes are contemplated in the legislation concerning this question; these changes are provoked by the considerable development of automobile traffic. In addition work is in hand on the drafting of a new law relating to railways, which takes into consideration the growing intensity of road traffic.

On lines of local importance, a new law modifies the existing rules in the sense that gates are not provided except on positive instructions from the Authorities.

Moreover, a special decree of the Minister for Railways is to be published, dealing with safety at level crossings as affected by the development of modern road traffic.

In Turkey the rules prescribe compulsory stopping of road traffic at an unprotected crossing, when the train is visible or when the whistle of the locomotive is heard.

The Railway Administration accepts no responsibility in case of accident at unprotected crossings.

In Jugoslavia the question of level crossings is subject to the law affecting railways, of the year 1930.

The ministerial decree of 1929 puts into force the rules of the U. I. C. concerning warning signals at the crossings of the railway and public roads, in connection with the development of automobile traffic and, by virtue of the above law, administrative regulations have been published as regards:

1. indicators and warning signals at non-protected crossings; 2. visibility at the crossings, and 3. the removal of barriers.

Question 3. — *What are the laws and rules with regard to traffic on roads in proximity to level crossings? Is the stopping of road vehicles obligatory before traversing the level crossing (unprotected)?*

In Germany § 79 of the E. B. & B. O. requires the stopping of vehicles at unprotected crossings on the approach of trains.

As regards automobiles, these are subject to the law of the 15 July, 1930: *Verordnung über Kraftzeugverkehr,* § 18/1 and/2, of which the following is the gist:

1. The speed of approach should be such that the driver can make himself master of the vehicle.

2. If the view of the railway is obscured, if the state of the road surface is such as to raise any doubt as to safety, or if the intensity of the traffic is very great, it is necessary to travel so slowly that the vehicle can stop in the shortest distance.

The courts interpret this text thus: the driver on approaching the crossing must take notice of all the dangers menacing

him and, if these are accumulating, he must reduce his speed as much as possible or come to a standstill.

In order to make the driver take the greatest care, the Government proposes to extend § 18/2 of the above regulation, by adding a clause to the effect that, in the event of there being any doubt as to whether a train is approaching the crossing, the speed of the vehicle ought to be such as to permit the driver to stop it before reaching the crossing. Another clause of the regulations in question forbids drivers to race against one another at crossings, for this is a frequent cause of accidents.

In Bulgaria the law directing the policy of railways is explicit with respect to this.

In Poland the movement of road traffic in the proximity of level crossings is regulated by the requirements of the ministerial decrees of the 6 July 1922 (automobile traffic) and of the 26 June 1924 (horses and pedestrians). At road crossings, motor vehicles are obliged to slow down to 10 km. (6.2 miles) per hour and other vehicles to 6 km. (3.7 miles) per hour. In order to ensure the safety of traffic, a regulation is proposed which will require all vehicles to stop at unprotected level crossings.

In Czechoslovakia in addition to the laws and regulations mentioned in §§ 1 and 2, there are instructions relating to the placing, at crossings, of warning boards.

These regulations will cease to be valid after 1934, when the boards will be replaced by warning crosses.

There are no requirements in existence as to the compulsory stopping of vehicles at unprotected level crossings.

In the other countries there are neither laws nor any particular regulations.

The stopping of vehicles at crossings is compulsory only in Jugoslavia; in Poland the establishment of a new scheme of regulations governing the crossing of roads with railways is under discussion. These regulations are in preparation, but they have not yet been published.

In the other countries this obligation does not exist.

Question 4. — *Have the recommendations of the International Convention of 1926 concerning automobile traffic on roads been introduced on your system and in particular:*

a) *Have there been adopted, and on what routes, the triangular signals indicating the proximity of a crossing with the railway, recommended in artice 9 of this Convention.*

b) *Have these signals been erected at distances of 150 to 250 m. (492 to 820 feet) from the level crossing, as recommended by the Convention, and in addition, has experience demonstrated the need for supplementary signals in proximity to the level crossing?*

The warning signals recommended by the 1926 Convention have been introduced in Germany, Bulgaria, Jugoslavia, Poland and Czechoslovakia, amongst the countries comprised in this report.

These signals are placed at a distance of from 150 to 250 m. away from the level crossing, as determined by the Convention.

Germany limits this distance to 200 m. (656 feet).

In Germany the respective requirements are to be found in *Verordnung über Warnungs-tafeln für den Kraftfahrzeugverkehr* (Law regulating the provision of warning boards for road motor traffic) of the 8 July 1927. In conformity with this law and with the orders which have been added thereto by the various countries of the Reich, triangular signals must be placed on important roads carrying long-distance traffic (Durchgangsstrassen).

The use of these triangles has been extended to nearly all crossings having heavy automobile traffic, even when

their provision is not enforced by statutory requirements. Experience has not demonstrated the necessity of adding other supplementary signals. At the present time a scheme is being discussed for adding, in certain cases, to the triangular boards, distance indicators (Entfernungsbacken) similar to the ones introduced in Switzerland by the following law : *Verordnung betreffend den Abschluss und die Signalisierung der Niveaukreuzungen der Eisenbahnen mit öffentlichen Strassen und Wegen* (Act regulating the provision of barriers and signals at railway level crossings).

Bulgaria has introduced in April 1928 the recommendations of the 1926 Convention. The triangular signals are placed on some of the more important national highways. Supplementary signals are not in use.

In Poland, in conformity with the Convention, warning signals are placed on all roads having a hard surface and, in general, on all the public roads which are suitable for high-speed motor car traffic.

In Czechoslovakia, triangular signals are placed on roads carrying automobile traffic. Supplementary signals are not considered necessary.

In Jugoslavia the recommendations of the Convention are applied on all national highways. Experience does not indicate the necessity of introducing other supplementary signals in the proximity of crossings.

Question 5. — *Are the requirements regarding the protection of level crossings on main lines equally applicable on lines of secondary importance?*

In Germany the existing laws require that all crossings on main lines (Hauptbahnen) shall be provided with barriers, whilst on secondary lines (Nebenbahnen) this is obligatory only in certain cases (see the reply to question 7).

In Bulgaria the regulations concerning the protection of level crossings are not applicable to lines of secondary importance.

In Poland the regulations which are at present in force control the question of the protection of level crossings on all lines of standard gauge; for narrow-gauge lines special, less stringent, rules are about to be issued.

In Czechoslovakia the regulations for main lines are equally applicable, in principle, to secondary lines of local importance and to certain private sidings. On account of the maximum speed allowed on the latter (normally 15 km. = 9.3 miles per hour), other more rigorous measures are not introduced, except those regarding the installation of warning crosses before level crossings in general, and warning posts, where unfavourable visibility conditions exist.

In Jugoslavia, in general, the regulations concerning the protection of level crossings on main lines are equally applicable to secondary lines, except that the posts which mark the spot on the line where the driver must give the warning signal with his steam whistle, are placed nearer to the crossing (200 m. = 656 feet).

The other systems have no special rules under this heading.

Question 6. — *Are there in existence any regulations making provision for the replacement of level crossings by bridges in the case of a certain number of trains or of a certain density of road traffic, and what is this number of trains and this density of traffic?*

These regulations exist only in *Poland* in the law of the 2 July, 1924, according to which crossing on the level is not permissible if a main line with intense traffic (above 30 trains daily in one direction), intersects an urban street or a public highway with heavy traffic (above 1 000 vehicles in 24 hours in one direction).

Any infraction of this regulation re-

quires the approval of the Minister of Communications in each particular case.

In Czechoslovakia in view of the technical and economic advantages resulting from the viaduct form of crossing, a programme spread over several years, has been drawn up, for the abolition of level crossings with intense traffic and situated under unfavourable conditions on main lines.

These questions are investigated in co-operation with the Minister of Public Works.

Czechoslovakia does not possess any special regulations under this heading.

Question 7. — *Please indicate the classification of level crossings from the point of view of supervision or of signalling, as provided by the regulations, taking into consideration the density of the road traffic, the nature of the railway, the number and speed of the trains.*

In Germany, acording to §§ 18/3 and 46/5 of the E. B. B. O. — excluding main line crossings which, as was described in question 5, should all be provided with barriers — to all other crossings the following rules are applied:

Visibility.		Speed of train at the crossing, (in km. - *in miles* per hour.)	Must barriers be provided?	Is supervision enforced?
Good	with heavy traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	Yes	Yes
		> 40 (25)	Yes	Yes
	with light traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	No	No
		> 40 (25)	No	Yes
Bad	with heavy traffic	< 15 (*9.3*)	Yes	No
		15-40 (*9.3-25*)	Yes	Yes
		> 40 (25)	Yes	Yes
	with light traffic	< 15 (*9.3*)	No	No
		15-40 (*9.3-25*)	No	No
		> 40 (25)	No	Yes

In exceptional cases, concessions may be made, but more stringent measures may be imposed.

Details will be found in Chapter III of the questionnaire.

In Bulgaria level crossings are classified as follows :

a) Crossings under permanent supervision;

b) Crossings under occasional (optional) supervision;

c) Crossings with no supervision.

The crossings are differentiated according to the density of road traffic, as follows:

1. heavy traffic;
2. medium traffic;
3. light traffic.

In Poland the new regulation for ensuring the safety of traffic at level crossings allows for the four categories as under:

I. Unguarded crossings, without barriers and without automatic signalling on the approach of a train.

II. Unguarded crossings, without bar-

riers but with automatic signalling on the approach of a train.

III. Crossings with a resident gatekeeper, closed during the passage of a train or normally closed.

IV. Crossings with barriers remotely operated, closed during the passage of a train.

There may also be crossings intended for a particular purpose, normally kept closed, which the users can open at need.

Very busy crossings (the total number of trains in 24 hours and the number of road vehicles per hour having a maximum density above 200) ought to be classed in category III.

In addition, crossings, where the highway intersects more than two main railway tracks or where it cuts lines used for shunting purposes at stations, must be supervised and classed in category III or IV, according to the decision of the Administration.

Those crossings where the traffic is less dense than mentioned above (the total trains in 24 hours and the number of road vehicles in one hour not being greater than 200) when visibility is adequate, are comprised in category I.

In category I are also classed all crossings where the speed of the trains does not exceed 15 km. (9.3 miles) an hour, without regard to the density either of the rail or road traffic.

When the visibility at these crossings is insufficient, they are classed in categories II, III and IV.

Concessions are allowed for those lines on which the speed of trains is limited to 50 km. (31 miles) an hour; on these lines, in category I may be classed the crossings which in no way comply with the conditions of visibility, if the total road traffic does not exceed 150 vehicles in 24 hours in the two directions, when motor vehicles only pass infrequently and when the number of motor buses is small.

In Czechoslovakia the level crossings are classed acording to their importance considering, above all, the density of road traffic (and also the density of railway traffic) as follows:

a) crossings of paths, country lanes and forest tracks which are in general frequented by natives of the country and people acquainted with local conditions;

b) crossings of communal lanes of greater importance, of communal, parish, departmental, regional and national roads carrying a small amount of traffic;

c) crossings of lanes and roads as under *b*) but whose traffic is greater.

Turkey (State Rys.) has no definite classification.

The Smyrna-Cassaba Railway classifies level crossings as:

1. Guarded crossings.

2. Unguarded crossings.

In Jugoslavia these are differentiated in conformity with the law relating to level crossings:

a) crossings provided with barriers, operated by railway employees.

b) crossings without barriers.

The density of the road traffic, the nature of the railway and the number of trains determine where the barriers are to be provided.

The Ministry of Communications, in agreement with the administrative authorities, decides in each case where the barriers are necessary.

Question 8. — *Do the laws or regulations give to the railway authorities the right to force the owners of adjoining lands to remove existing obstacles, in order to obtain sufficient visibility from the level crossings?*

By virtue of the existing regulations dealing with the purchase of land and, in view of the right of the railway to acquisition, the owners of adjoining lands may be obliged to remove all exist-

ing obstacles which are harmful to visibility, in *Germany* and in those parts of *Poland* which formerly formed part of Germany and of Austria.

By virtue of these same provisions, all changes on lands adjoining the railway, which might be harmful in an inadmissible manner to visibility, may be prohibited.

Czechoslovakia, Jugoslavia and the parts of *Poland* which have different legislation in this respect can obtain the above results only by acquisition.

In this part of Poland in Czechoslovakia the construction of new buildings on certain lands adjacent to the railway may be prohibited in conformity with the existing laws and regulations.

In Czechoslovakia railway legislation prohibits the carrying out of works, in the neighbourhood of the railway, which might endanger the safety of traffic.

By virtue of this legislation, the railway authorities can require the administrative authorities (cantonal) to forbid the carrying out of works which might interfere with visibility at level crossings.

The railways of other countries have no such rights.

Question 9. — *Is the line protected by a hedge or in any other way in the proximity of a level crossing, and if so, is it the result of custom or of a regulation ?*

No State possesses proper regulations.

In Czechoslovakia, at busy crossings where the location and safety of traffic require it, the line is generally protected by various kinds of enclosures; quickset hedges, fences, etc.

In Turkey, in the neighbourhood of level crossings, the line is sometimes protected for a length of about 10 m. (33 feet) on each side by a fence composed of old rails, small planks or barbed wire, to meet local needs.

In Jugoslavia the railway line is protected by a hedge or otherwise in the proximity of a level crossing; this is a matter of custom.

In Germany there is a law for main lines only, which requires fencing in places where the location of the track and the customary protection do not suffice for preventing people from crossing the line. On lines of local importance it is usual to erect fencing if the approaches to the crossing are on a gradient. Recently doubts have been raised as to the necessity of providing fencing at crossings, for, in the event of a collision between a train and a motor vehicle, the fencing might agravate the consequences of the accident.

Question 10. — *Kindly indicate, in a general manner, the proportion in which the different public bodies participate in the cost of providing and maintaining the various means of protection occasioned by the increase in road traffic.*

This question has been tackled in the most definite manner by *Poland* where on ordinance of 2 July 1924 declares that in case of reconstruction of an existing crossing the cost should be borne either by the railway or road administration according to which body has initiated the reconstruction.

In Germany the proportion in which the costs are borne is not fixed. The regulations affecting railways provide only that the costs should fall upon the railway or the road authority as the railway traffic or the road traffic necessitates the protection of the crossing. If the measures taken are provoked by the needs of both road and rail traffic, the two parties bear the cost in proportion to the financial advantages which accrue to them by this investment.

In case of dispute the Ministry of Communications decides.

In Czechoslovakia this proportion is not determined in any precise manner. The expenditure incurred on road equipment and works, rendered necessary by the development of mechanical trans-

port, in the neighbourhood of the railway or even on the railway itself, is assumed, in common, by the railway and by the public bodies concerned pro rata with the advantages accruing to them.

On the *Smyrna-Cassaba Railway* no public body shares expenditures relating to level crossings.

In Jugoslavia, when it is a question of abolishing level crossings in order to replace them by a bridge, the railway administration negotiates the cost with the interested public bodies and, if agreement is reached, the proportion in which each of the different bodies will participate in the cost is determined.

The other Systems have no regulations on this subject.

Question 11. — *What are the means of announcing to the public using the roads, the methods of protecting level crossings, other than the publication of the usual rules?*

In Germany the arrangements are made known to the public by means of notices posted in the stations. All alterations to these provisions are, in addition, published in the newspapers.

In Poland, besides the publication of these regulations by official means, notices with the text of the warnings to the public are posted at the crossings themselves.

The *Smyrna-Cassaba Railway* posts this kind of notice only on the more important roads.

In Czechoslovakia the public is informed only by the administrative authorities when changes in the manner of protecting crossings are introduced.

In Jugoslavia the principles of the measures taken are brought to the knowledge of the public by explanatory posters displayed in stations, as also by the administrative bodies.

The other systems make no arrangements under this heading.

CHAPTER II.

Statistics.

Question 1. — *Kindly state the number of public level crossings and the definition of the different categories resulting from laws or regulations, with the indication as to whether they are supervised or not.*

The respective systems have communicated to us the following data:

Germany. On 1 December 1928, there were 75 522 level crossings on the German Railways, of which :

a) Crossings with gates or other barriers: 33 930.

b) Unprotected crossings : 41 592.

Bulgaria.

	Length of lines in km. (*in miles*).	Categories *.			Total.
		I	II	III	
Single track	2 575 (*1 600*)	54	196	1 812	2 062
Double track	...	...	...	...	...
More than 2 tracks. . .	...	..	...	...	...

* Definition of the categories :

I. Permanently guarded crossings.

II. Occasionally guarded crossings.

III. Unguarded crossings.

Poland.

	Length of lines, in km (*in miles*).	Categories *.			Total.
		I	II	III	
Single track	12 515 (7 777)	11 158	1 785	2 174	15 117
Double track	4 884 (*2 786*)	2 133	1 347	1 125	4 605
More than 2 tracks . . .	53 (*33*)	5	25	10	40
Total. . .	17 452 (*10 596*)	13 296	3 157	3 309	19 762

* Definition of the categories :

I. Unguarded open crossings.
II. Crossings guarded by a resident gatekeeper, closed during the passage of a train or normally closed.
III. Normally closed crossings, attended to from a distance.

Turkey (Smyrna-Cassaba Railway).

	Length of lines, in km. (*in miles*).	Categories *.			Total.
		I	II	III	
Single track	700 (*435*)	33	733	...	766
Double track	2 (*1.2*)	...	...	...	...
More than 2 tracks . .	...	...	...	...	...
Total. . .	702 (*436.2*)	33	733	...	766

* Definition of the categories :

I. Guarded crossings.
II. Unguarded crossings.

Czechoslovakia.

	Length of lines, in km. (*in miles*).	Categories *.			Total.	Of which	
		I	II	III		Closed or guarded.	Unguarded.
Single track	11 332 (7 *042*)	14 756	4 722	2 493	21 971	7 009	14 962
Double track	1 735 (*1 078*)	713	575	303	1 591	1 487	104
More than 2 tracks . . .	14 (*9*)	3	8	4	15	15	—
Total. . .	13 081 (*8 129*)	15 472	5 305	2 800	23 577	8 511	15 066

* Definition of the categories :

I. Crossings with country lanes and forest tracks, used principally by natives of the country and people acquainted with the country.
II. Crossings with public highways of considerable importance (communal, parish, departmental, regional and national roads), but carrying a small amount of traffic.
III. Crossings with highways mentioned under II, but with a greater amount of traffic.

Turkey (State Railways).

	Length of lines, in km. (*in miles*).	Guarded.		Unguarded.		Total.
		With gates.	Without gates.	With gates.	Without gates.	
Single track	2 440 (*1 516*)	54	22	24	1 599	1 699
Double track	24 (*15*)	3	1	...	1	5
Total. . .	2 464 (*1 531*)	57	23	24	1 600	1 704

Jugoslavia.

	Length of lines in km. (*in miles*).	Categories *.			Total.
		I	II	III	
Single track	6 375 (*3 961*)	1 292	693	6 426	8 411
Double track	545 (*339*)	370	272	41	683
More than 2 tracks . . .	3 (*1.9*)	1	1	1	3
Narrow gauge.	3 300 (*2 050*)	92	26	2 924	3 042
Total	10 223 (*6 351.9*)	1 755	992	9 392	12 139
Within the station precincts :					
a) Standard gauge		128	32	31	191
b) Narrow gauge.		5	...	...	5

*Definition of the categories :

I. Crossings provided with barriers operated on the spot or from a distance of not more than 50 m. (165 feet.)
II. Crossings provided with barriers operated at a distance of more than 50 m. (165 feet).
III. Unguarded crossings, with warning signals, where the users of the road are responsible for ascertaining whether a train is approaching.

Question 2. — *What is the number of underline or overline crossings with roads carrying motor traffic?*

In Germany there are 6 907 overline crossings and 17 865 underline crossings; in Bulgaria 24, in Poland 1 174, in Czechoslovakia 1 234, in Turkey 19, in Jugoslavia 67 overline, and 145 underline crossings.

Question 3. — *What is the annual number of accidents at level crossings since 1926; kindly say how many out of this number were collisions between trains and motor vehicles, and how many collisions of motor vehicles with closed barriers.*

Germany sends the following information about automobile accidents (motor bicycles excepted) having serious consequences (passengers wounded or killed, vehicles badly damaged).

Germany.

	1926	*1927*	*1928*	*1929*	*1930*
1. Total number of accidents at crossings on the German Railways (without counting narrow gauge lines)	93	145	159	163	129
of which:					
a) at crossings having barriers	42	60	56	60	43
b) at crossings without barriers	51	85	103	103	86
2. Causes of the accidents:					
a) Fault of the railway employees	15	24	18	25	22
of which:					
1. Defective supervision of the barriers	14	24	18	23	18
2. Other causes	1	—	—	2	4
b) Fault of the road vehicle drivers	67	108	127	135	106
of which:					
1. Closed, destroyed or open barriers	16	30	25	30	21
2. Negligence with regard to warning signals and the whistling of the locomotive	51	78	102	105	85
c) Other causes known and unknown	11	13	14	3	1
3. At the crossings on the German Railways there were during the passage of motor and other vehicles:					
a) in killed and injured	193	259	237	193	134
of which were killed	48	67	45	64	33
b) of motor vehicles only killed and injured	109	178	181	153	113
of which fatalities	23	46	33	57	29
of which persons killed at crossings provided with barriers	8	22	13	29	11
c) passers-by killed or injured	—	42	19	60	66
of which have been killed	26	31	12	33	36

Bulgaria had 10 accidents during this time. The Smyrna-Cassaba Railway (*Turkey*) had 1 to 2 accidents yearly.

In *Poland* the number of accidents which occurred at level crossings since 1926 is the following:

Total number of accidents:	*1926*	*1927*	*1928*	*1929*	*1930*
a) At supervised crossings	120	181	55	57	64
b) At unsupervised crossings			128	147	111
Number of persons killed:					
a) At supervised crossings	—	—	15	23	27
b) At unsupervised crossings	—	—	34	40	35

Causes of accidents in 1930.

1. *At supervised crossings:*

Fault of railway employees	26	(40.6 %)
Caused by negligence of passers-by	34	(53.1 %)
Due to mistakes and other causes	4	(6.3 %)

2. *At unsupervised crossings.*

Caused by negligence of passers-by	110	(99.1 %)
Fault of engine driver	1	(0.9 %)

Collisions of motor vehicles with closed barriers have not been reported.
Czechoslovakia communicates the following data:

Year.	Total number of accidents.	Collision of trains with motor cars and vice-versa.	Motor cars colliding with closed barriers.	Remarks.
1926	327	46	205	
1927	449	64	304	
1928	522	82	358	
1929	593	70	418	
1930	684	101	495	
1931	490	69	356	
Total.	3 065	432	2 136	December (1931) excluded.

Jugoslavia, since 1926, had an average of 44 accidents per annum, of which annually, 18 collisions were between trains and motor vehicles and 26, that is to say 60 % of the total, were collisions with closed barriers.

Question 4. — *Kindly state the number of level crossings replaced by underline or overline bridges since 1926, for each year separately if possible, as a result of the increase of mechanical transport on roads.*

In Germany, since 1926, very few crossings used by intense traffic have been replaced by bridges. The construction of the bridges has not been prompted solely by the increase in automobile traffic.

For the time being it is not possible to accelerate the replacement of level crossings by bridges on account of the unfavourable financial situation, as much for the railways as for the road authorities.

In Bulgaria there has been constructed since 1926, 5 under- or overline bridges, *in Poland* 7, in *Czechoslovakia* 53, in *Turkey* 1, in *Jugoslavia* 5.

CHAPTER III.

Protection of level crossings.

A. — Supervision.

Question 1. — *If you possess any supervised level crossings, but not provided with barriers, kindly state the reasons justifying this method of protection.*

All the systems reply to this question that in principle they do not adopt this method of protection, with the exception of Czechoslovakia and Turkey.

In Czechoslovakia level crossings without barriers are only supervised in exceptional cases on lines with train speeds of from 40 to 50 km. (25 to 31 miles) per hour. The reason is usually very intense road traffic and the lack of visibility.

Turkey replies in the affirmative, adding that it is done for economic reasons, without entering into other details.

On the *German* Railways there are few crossings of this kind. This method of control is permissible by the regulations (E. B. B. O.), which, in certain cases (Cf. Ch. 1, § 7), provide for supervised crossings but not furnished with bar-

riers. These regulations also permit the use of unsupervised crossings in the cases where the speed of trains is less than 40 km. (25 miles) per hour. The already existing barriers must be made use of before the passage of all trains. It is intended to abolish the supervision of the above mentioned crossings and to instal instead an optical signalling system in order to reduce maintenance costs, but this will only be done after adequate experience has been gained with optical signalling.

Bulgaria does not employ this method of control.

In Poland this method of control is not in use. Its application is provided for in case of damage to the automatic signalling system, which announces the approach of trains to the crossing.

In Jugoslavia it is only exceptionally that such crossings are supervised for one cause or another (on the occasion of special trains).

Question 2. — *Are there in existence barriers closed automatically on the approach of the train? What are in this case the form of construction, the method of working, the cost of providing and operating these barriers?*

No railway system possesses barriers of this description. *Germany* points out that they do not use barriers of this type as they increase the risk of shutting up a vehicle on the level crossing.

Question 3. — *Please state if you instal special warning signals in the neighbourhood of level crossings equipped with barriers, independently of the signals recommended by the International Convention in Paris, 1926, relative to automobile traffic. (Kindly give a description of these signals and of their location).*

This is done only in *Germany*. In the immediate proximity of crossings closed by barriers, warning signals of a special shape, a sort of half-cross, are placed (see fig. 1). These signals, prescribed by the E. B. B. O., § 18 (9), enable the driver of a vehicle to inform himself, especially on curves, of the proximity of a crossing. Since the installation of these signals on the German Railways an appreciable reduction in the number of barriers damaged by motor vehicles has been recorded.

Question 4. — *Are the barriers fitted with fixed signals during the day and with red lights during the night in order to make them more easily visible?*

The *German Railways* intimate that installations of this kind were formerly used in particular cases. They have an objection, that of being masked by vehicles standing in front of the closed crossing, and then they do not fulfil their duty.

The indispensable standardisation of the signalling system would make obligatory the installation of these signals at all crossings, which, in view of their doubtful efficacy, can not be entertained.

The German Railways have abandoned this system since the introduction of another one which consists of painting the barriers in white and red stripes. These barriers, well illuminated, form an obstacle visible from far away.

In Poland lamps with an orange light are used at certain crossings; however, the new regulations make no provision for these but stipulate a general illumination of crossings carrying intense traffic.

In Czechoslovakia the horizontal members of the barriers, on roads with considerable automobile traffic, are furnished, in the middle, with a red signal lens behind which is hung a lamp during the night. When the barrier is closed, the lamp takes its position behind the red lens and projects a red beam of light along the road. When the barrier is raised the lamp changes its position and projects a white beam. In the case of important roads having much traffic, lenses with red reflectors are fixed to

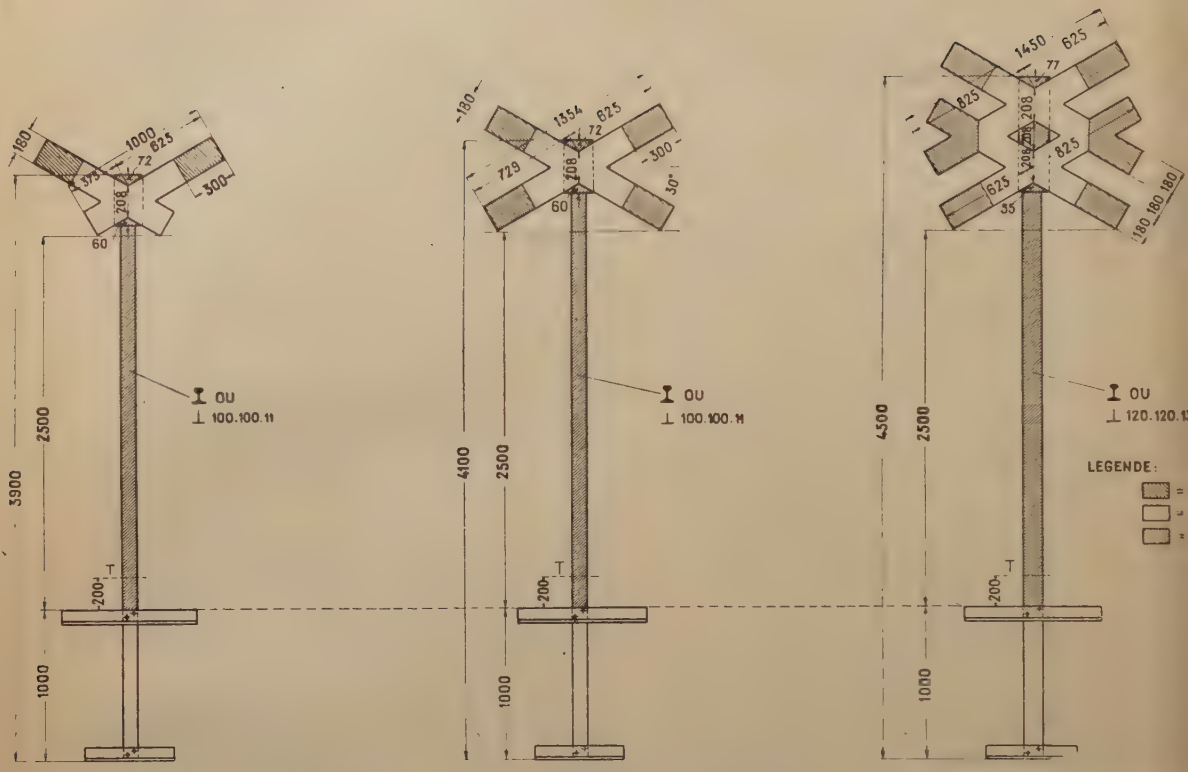

Fig. 1. — Signal at crossings with barriers.

Fig. 2. — Signal at single-track crossings without barriers.

Fig. 3. — Signal for multipl crossings without barrie

Note. —Ou = Or. — Rouge = Red. — Blanc = White. — Gris = Grey.

the barriers for the purpose of warning drivers at night time of the presence of a level crossing.

Turkey gives an affirmative answer without entering into details.

In Jugoslavia the barriers are painted in black and white stripes in order that they may be easily visible during the day. During the night some very busy crossings in towns are provided with red lights.

The other systems use neither fixed signals nor red lights during the night.

Question 5. — *At what interval of time before the arrival of a train ought the barriers to be closed? In what manner is the moment announced at which the gatekeeper must close the barriers?*

The replies shew that the intervals of time vary greatly. The extreme limits are: an interval of 2 minutes in *Poland,* and that from the moment of departure of the train from the neighbouring station in *Bulgaria.*

Bell signalling is used on several systems.

In Germany the precise moment for closing the barriers is not fixed. The approach of the train is signalled by the ringing of a bell at the moment when the train passes the last signal box. So far as the closing of the barriers at the cor-

rect moment is concerned the gatekeeper must be guided by the timetable bearing in mind the different speeds of the trains and also the fact that certain trains may pass before the time shewn in the timetable.

In Bulgaria the barriers must be closed after the departure of the train from the neighbouring station. On main lines where the stations are equipped with bell signalling apparatus, the departure of the train is announced by this means.

Poland. In general, the barriers must be closed at least 2 minutes before the arrival of the train. For some special crossings, the local authorities can in exceptional cases advance or delay the closing of the barriers. The gatekeeper should above all be guided by the timetable.

In Czechoslovakia all barriers are closed at least 5 minutes before the arrival of the train at the level crossing. The regulations permit this interval to be shortened in exceptional cases, but only in the immediate proximity of a station and when the gatekeeper is advised without any doubt of the approach of the train. The warning is given by bell signals (when they exist), otherwise the gatekeeper works to the timetable which is displayed at his post. When there is telephonic communication the station notifies the gatekeeper of any delay to trains, when this exceeds 10 minutes. The signalman is guided by a previous announcement.

In Turkey (State Railways) the barriers are closed 3 minutes before the arrival of the train in normal weather and 5 minutes in case of fog.

The drivers of trains running late must give a long warning signal at 2 km. (1.2 miles) away from the crossing. The moment of closing the barriers is not previously announced.

The gatekeepers must work to the timetable.

On the *Smyrna-Cassaba Railway* the barriers close on the approach of the train.

In Jugoslavia the barriers must be closed 5 minutes before the arrival of the train. The gatekeeper must be guided by the electric bells or by telephone messages. When there is no electric bell nor telephone he must be guided by the train schedule.

Question 6. — *Kindly indicate whether, on your system, there are barriers normally closed, which are opened to road traffic only after verifying that no train is approaching the level crossing.*

In Germany in conformity with § 46 (9) of the E. B. B. O., on quiet lines the barriers at crossings may remain closed in agreement with the police authorities. As to unsupervised crossings on private roads, in accordance with § 46 (10), the barriers must remain closed.

Bulgaria, Turkey (State Railways and Smyrna-Cassaba Railway), have no level crossings with barriers normally closed.

In Poland this method of protection is now utilised especially on private crossings. In the new rules the possibility is foreseen of applying this system to crossings where the road traffic is slight whilst the railway traffic is considerable.

In Czechoslovakia there are no such crossings, except that a few country lanes are normally closed by gates which are only opened on the request of those interested.

Question 7. — *Do you use barriers pivoting on a horizontal axis, barriers on vertical axes, barriers sliding longitudinally or other systems; such being the case, kindly indicate the percentage of the total of crossings closed by barriers of each group with description of the systems and enumeration of their advantages.*

In Germany there are used at present almost exclusively barriers pivoting about a horizontal axis transversely with the centre line of the road. Sliding bar-

riers, chains and other systems are only employed rarely.

In Bulgaria the bulk of the barriers have a horizontal axis. There are also some having a vertical axis. The first are considered to be the best.

In the other countries the percentage works out as follows:

a) barriers pivoting about a horizontal axis;
b) barriers pivoting about a vertical axis;
c) barriers sliding longitudinally;
d) other systems.

	a)	*b)*	*c)*	*d)*
Poland	90	4	3	3
Czecho-Slovakia . . .	96	3.2	0.8	...
Turkey (State Rys.) . .	100	...	...	...
Turkey (Smyrna-Cassaba)	66	...	34	...
Jugoslavia	57	14	29	...

Question 8. — *Are the two barriers at a crossing operated simultaneously by a single mechanism or separately? Kindly state the percentage of each variety:*

a) *Level crossings with barriers operated simultaneously by a single mechanism;*

b) *Level crossing with barriers operated separately.*

	a	*b*
Germany	Represents normal practice.	This system is recommended for very wide roads with intense traffic, where pedestrian and vehicular traffic does not cease, so that it is not always possible to close the two barriers simultaneously.
Bulgaria	...	Represents normal pratice.
Poland	78 °/₀.	22 °/₀ temporary installations on lines of small importance.
Czechoslovakia	Represents normal practice.	7.2 °/₀.
Turkey (*State Rys*) . . .	Represents normal practice.	...
(*Smyrna-Cassaba*) . . .	2 level crossings.	Represents normal practice.
Jugoslavia	80 °/₀.	20 °/₀.

The two barriers at level crossings operated at a distance are put into motion simultaneously on all the systems, by a single mechanism.

Question 9. — *Kindly state the distance between the barrier and the centre line of the nearest track.*

In Germany this distance is generally from 3 to 5 m. (9 ft. 10 in. to 16 ft. 5 in.). This figure is often increased for barriers operated at a distance with the object of having enough space between the barrier and the track to accommodate a vehicle which might accidentally get shut up there. This is, however, only done when local conditions require it, if the spacing of the barriers at more than 5 m. does not diminish visibility along the road from the post of the gatekeeper and the visibility of the railway from the road. To a certain extent increased spacing of the barriers may be the cause of locking up vehicles between

the barriers, by increasing the length of the dangerous zone.

In Bulgaria this distance is fixed at 3 m. (9 ft. 10 in.) for barriers with a horizontal axis and at 7.50 m. (24 ft. 7 in.) at least for those with a vertical axis.

In Poland according to the ordinance of the 2 July 1924, the barriers must be placed at a distance of 8.50 m. (27 ft. 11 in.) at least from the nearest rail of the track [about 9.30 m. (30 ft. 7 in.) from the centre line of the track].

On many crossings the barriers are placed nearer, up to 3 m. (9 ft. 10 in.) from the centre of the track ; according to the new regulations, this distance of 3 m. must remain the minimum for the distance allowed for barriers operated on the spot and by the same mechanism, as well as for those which are operated at a distance, if they are easily visible from the gatekeeper's post and if appliances at the site enable them to be opened to persons accidently imprisoned between the barriers.

In Czechoslovakia : a) the distance from the rail of the barriers to the centre of the adjacent track must be as a general rule 6.75 m. (22 ft. 2 in.) a figure which, in exceptional cases, can be reduced to 3 m. (9 ft. 10 in.). At the same time, all the barriers operated at a distance must be furnished with an automatic bell signalling apparatus, which must ring for a time not less than that strictly defined.

b) For barriers mentioned under *a*), situated at a distance of less than 50 m. (164 ft.) from the gatekeeper's post, whence they are operated, the warning bell is not necessary if these barriers are easily visible from this post.

c) So far as barriers provided with warning bells are concerned, but when the conditions are not of such a nature as to exclude the possibility of shortening the time prescribed for ringing, the distance from the rail of the barriers to the centre of the adjacent track should be 8.35 m. (27 ft. 5 in.).

d) The minimum distance between the barrier and the centre of the adjacent track, say 8.35 m. must be maintained even for barriers operated at a distance, which do not possess any warning bells, whether such barriers come under the conditions referred to under *b*) or not.

The same arrangements apply equally to barriers operated by hand.

In Turkey, on the State Railways, the distance is an average of 3.50 m. (11 ft. 5 3/4 in.) and on the Smyrna-Cassaba Railway from 5 to 10 m. (16 ft. 5 in. to 32 ft. 4 in.).

In Jugoslavia the maximum distance is fixed at 3.75 m. (12 ft. 3 1/2 in.) for standard gauge lines and at 2.50 m. (8 ft. 2 in.) for narrow gauge lines. But there are also barriers at a greater distance from the track (up to 12 m. = 39 ft. 4 1/2 in.).

Question 10. — *If you have any barriers operated from a distance, kindly indicate the regulations concerning the maximum distance from the gatekeeper's post, the maximum number of barriers operated by the same gear, and finally, the visibility distance of the level crossing, without an attendant on the spot, from the gatekeeper's post.*

Poland alone has precise regulations regarding this distance which is fixed at 800 to 1 000 m. (2 624 to 3 280 feet).

In practice the following distance are maintained :

In Germany about 300 m. (984 feet) and, for crossings with inconsiderable traffic, on country roads 600 to 700 m. (1 968 to 2 296 feet).

In Bulgaria 800 m. (2 624 feet).

In Czechoslovakia 1 500 m. (4 920 feet).

In Turkey (State Rys.) 200 m. (656 feet) because the greater number of barriers operated at a distance are situated near to stations.

In Jugoslavia 1 500 m. (4 920 feet).

In Germany barriers operated at a distance are permissible, by virture of § 18 (4) of the E.B.B.O., only when the traf-

fic is light and they must be easily visible from the gatekeeper's post.

The distance is not fixed by any regulations. It is required that the crossing and its surroundings should be visible from the post, in normal weather, which agrees with the maximum distance of 300 m. (984 feet). So far as crossings on country roads with light traffic are concerned, the interpretation of this regulation is such that the visibility is considered sufficient when it is possible to distinguish whether the barriers are raised or lowered. As a result barriers are sometimes to be found situated at a distance of from 600 to 700 m. (1 968 to 2 296 feet) from the gatekeeper's post. Each barrier controlled from a distance is operated by its own transmission gear.

In Poland the number of barriers operated by the same gear is limited by the condition that the working of them should not be too difficult for the gatekeepers. According to the new Polish regulations the barriers cannot be controlled from a distance if the sum of the trains per day and of vehicles per hour of the most intense traffic exceeds 200.

In Czechoslovakia the number of barriers put in motion by the same transmission gear is 2 barriers on lines with much traffic and 3 barriers at the most on lines with little train traffic, when, between these barriers there is no stopping place and when the distance between the first and the second does not exceed 800 m. In this case the visibility of the barriers from the control post does not enter into consideration.

In Turkey 2 pairs of barriers at the maximum are put in motion by the same gear. There is no regulation regarding the visibility from the gatekeeper's post.

In Jugoslavia there are, as a maximum, 4 barriers put in motion by the same gear. The visibility of the level crossings from the gatekeeper's post is not stipulated. There are some distant level crossings which are not visible from the gatekeeper's post.

Question 11. — *What are the arrangements for preventing pedestrians or vehicles using the road, from being imprisoned between the two barriers of a level crossing controlled from a distance ?*

In Germany there exists, for that, means, foreseen by § 18 (5) of the E.B.B.O. The barriers are fitted with bell signals by means of which the impending lowering of the barriers it indicated. This signalling is set in motion in an automatic manner by means of a wire and gives 15 to 20 seconds before the lowering of the barriers at least 10 rings, and during the lowering another 5 rings at least. In order that any pedestrians or vehicles shut up in the crossing, may be able to set themselves free, the barriers must also be hand operated and when they are raised at 75° from the ground they must be capable of being pushed down by hand. The opening of the barriers by hand must be brought to the knowledge of the gatekeeper by means of a reverse indication, either by bell or by an optical signal.

In Bulgaria the ringing of a bell takes place several seconds before the closing of barriers operated at a distance.

In Poland two methods are in use :

a) The barriers, placed close to the track, are easily visible from the control post and can be opened, in case of necessity, by persons imprisoned in the crossing;

b) Between the barrier and the nearest track, on both sides of the railway, there is enough room for a fairly long vehicle; in this case, the visibility of the crossing from the control post is not rigourously determined. In these two cases the closing of the barriers ought to be announced by bells at the crossing. The working of the bells should be automatic, at least in the case where the barriers are not visible from the control post.

In Turkey (State Rys.) as soon as the wheel of the operating gear is turned, the bell at the level crossing gives 10

consecutive rings. If there should be, nevertheless, persons imprisoned between the barriers, they can open one of them by hand (for certain types of barriers only).

In Jugoslavia and *in Czechoslovakia* barriers operated at a distance of more than 50 m. (164 feet) are equipped with bells.

B. — Automatic signalling of trains at level crossings.

Question 1. — *Please state the number of level crossings furnished with automatic apparatus, warning the public of the approach and of the passage of a train, and kindly say what are the results of the use of these appliances.*

Automatic appliances, warning the public of the approach and passage of a train at the level crossing, exist only in Germany, in Poland and in Jugoslavia, in the nature of an experiment only and in limited numbers.

In Germany automatic signalling has been introduced up to the present on 5 crossings as an experiment. One of these installations, on a section of line having steel sleepers, has been working for only a short time and it is as yet impossible to give any verdict as to its efficacy.

Experiments made up to the present on other sections with timber sleepers, have given such good results that it is proposed to introduce automatic signalling on other similar sections in greater numbers.

In Poland 2 level crossings are already provided with the same kind of automatic signalling and on 9 others the work of installation is in hand. An acetylene signalling appliance, « Aga » system, is in active use since the month of October 1930, and is giving satisfactory results.

In Jugoslavia there is only a single crossing equipped with this form of signalling, it is also provided with barriers. This automatic apparatus has been installed several months ago in connection with the construction of an electric tramway which crosses the railway on the level, with the object of warning the tramway's staff of the approach of a train.

In Switzerland the following systems of automatic signalling are employed at the present time :

a) Flash light signals (Sigram type);
b) Flash light signals (Aga type), 4 installations;
c) Wigwag signals, 9 installations;
d) Helical form of signals (Hasler type), 4 installations.

All these systems have been installed experimentally. In the future only flash light signals will be employed, in conformity with article 4 *b* (1) of the ordinance of the 7 May 1929, which reads: « instead and in place of barriers there will be a uniform use of flash light signals, of triangular shape and having 3 red flash lights and a bell or warning siren ». These signals are all subject to disturbances from time to time. In general they have given satisfactory results.

Question 2. — *Are you of the opinion that these appliances can, without any restrictions, replace supervision; in the contrary case, kindly indicate the supplementary conditions of security in consideration of which these installations are allowable.*

In Germany it is considered that these appliances can completely replace barriers and supervision. When they are in common use and well maintained, cases of damage are certainly not more frequent than mistakes by the gatekeepers. As to road traffic, automatic signalling has the great advantage over barriers that the movement of traffic is not held up for a longer period than is necessary.

In Poland there is a firm opinion that these appliances properly installed and

maintained will be able definitely to replace the supervision of crossings. The final decision as to the extent of their adoption will only be taken after experience has been gained. The new ordinances on the safety of traffic at crossings make ample recognition of this system of signalling and supervision.

In Switzerland it is found that these appliances can, without any restriction, replace supervision. They require, however, most careful maintenance in order that they may function quite correctly.

Question 3. — *At what distance of the train from the level crossing does the automatic apparatus start to work? Do you possess any installations or have you made any trials of apparatus warning the public a certain time, arranged previously, before the arrival of the train at the crossing, that is to say, allowing for variable speeds of trains and beginning to function at distances from the level crossing, varying according to this speed?*

In Germany this distance depends on the maximum speed of the trains at the crossing and ought to be such that the warning signal can begin to function 30 seconds before the arrival of the train at the crossing, if the width of the crossing is normal. Up to the present the necessity has not arisen of using signalling apparatus with a constant period of working, before the arrival of the train, for now and in the future, automatic signalling will only be adopted on lines on which the variations in speeds of trains are relatively small.

In Poland according to the existing regulations the announcement of the arrival of the train should start at least 30 seconds before the arrival of the train at the crossing, and it should stop when the train leaves the crossing. In conformity with this lapse of time, the spot on the track is selected where the train, on arrival, lights the signal at the crossing, taking account of the maximum speed of the trains.

No experiments have been made with appliances which are regulated according to the variability in speed of the approaching trains.

In Switzerland contact rails are used actuating the flash light signals, taking into account the maximum speed authorised on the line in question in conformity with the prescriptions of article 4 *b* (2) of the ordinance of the 4 May 1929, which is worded : « The flashing of the lights or ringing of the bell or siren ought to begin from 30 to 45 seconds before the passage of the train and cease when the last wagon of the train has left the crossing. »

No system utilises a contact depending on the speed of the trains.

Question 4. — *Kindly say if you have adopted any standard type of optical apparatus (and in this case give a general description and indicate the colour, the number and the arrangement of the lights) or any audible apparatus for bringing the road traffic to a standstill. Is any signal provided for « road clear »?*

In Germany a standard type of optical signal is in use. If the train is not there, the signal shews a white light flashing about 40 times per minute. On the approach of the train the white light is masked by a coloured lens and shews a red light which flashes twice as fast as before. The change in the rate of flashing enables road users including even those affected by colour blindness to recognise the signal. When the light, white or red, does not flash, it is evident that the apparatus is damaged and the crossing of the track should be performed with very special precautions. In order that the signal, if extinguished, should not be overlooked by road users, especially by motor drivers, it is surrounded by a red and white frame of square shape. This frame, as

well as the warning cross placed above it, has a light-reflecting surface.

In Poland the signal « *stop !* » is given by red flashing lights. The number and arrangement of the lamps are not precisely stated. The signal « *road clear* » given by means of white lights, with fewer flashes than the red lights, is considered as supplementary by the proposed regulations, and its installation may be decided upon by the regional railway authorities, so as to meet the local traffic conditions.

In Switzerland according to the ordinance of the 7 May 1929, art. 4 *b* :

3) the number of flashes will be about 80 per minute.

4) the red light ought, as a general rule, to be obscured on the side facing the train.

5) the working of the signals ought, as a general rule, to be capable of being controlled by the crews of trains by means of yellow lights placed laterally to the signals themselves or of special indicator lamps, placed at suitable locations along the line.

In default of these arrangements, or in particular circumstances, electrical apparatus should be provided along the side of the line to check the line current or repeat the flash lights at the next station or at the nearest control post.

There is no special signal for « train approaching ». If the signal does not light up, pedestrians and vehicles can traverse the crossing. In this case the user of the road must assure himself that no train is approaching.

Question 5. — *Is the lighting provided by electricity (from the mains or a local battery) or by acetylene ?*

In Germany amongst the appliances mentioned under 1, there are three which are illuminated and energised by current from the mains, the fourth by electricity from local accumulators, the fifth, illuminated by acetylene, is energised by accumulators.

In Poland one of the experimental installations is illuminated by acetylene, the others by electricity supplied mainly from batteries of accumulators.

In Switzerland transformed current from the contact line and current from the local mains are used for the lighting of the flash light signals. The apparatus automatically switches itself on to the local main if the traction supply fails.

Question 6. — *Kindly state if you also instal at crossings fitted with apparatus for announcing the approach of trains, the fixed signals used where the approach of the trains is not signalled.*

In Germany warning crosses described under C1. are placed above the optical signal.

In Poland at these crossings, alongside the optical signal announcing the approach of the train, are installed indicators as at unsupervised crossings (III C, 1).

In Switzerland at level crossing furnished with appliances announcing the approach of trains, fixed signals are not installed, as they are at crossings where the approach of trains is not signalled.

Question 7. — *Kindly point out the means by which the protection of level crossings is effected, according to the regulations, in case of failure of the apparatus announcing the approach of trains.*

In Germany when the apparatus is damaged and it is impossible to repair it immediately, the crossing is protected on the spot.

In some cases, as an experiment, control devices which signal the failure of the apparatus to the neighbouring station have been installed. The staff on duty at this station must at once undertake preventive measures. It is not thought that these devices are necessary everywhere, for the failure of the apparatus is easily noticed by the users of the road.

In Poland, in a similar case, the crossing must be temporarily guarded by a railway employee. In the event of it being impossible to arrange this temporary supervision the speed of trains at the crossing must be reduced and signals by whistle or bell must be sounded on the locomotive. The same procedure is adopted when on a double line the movement of trains in both directions takes place temporarily on one line only.

C. — Arrangements for guiding road users.

Question 1. — *Are fixed signals in the form of a St. Andrew's cross installed at all unsupervised level crossings, or only at those where supervision has been recently withdrawn? Are there any level crossings with a single fixed signal visible from the two directions of approach of the road?*

In Germany with the exception of easily visible and little frequented crossings, on which by virtue of § 18 (9) of the E.B.B.O., cruciform signals are not obligatory, all the crossings on the main and secondary lines are provided with these signals, even those which were never closed or supervised. The cruciform signals are placed on each side, near the crossing, to the right, at a distance of 5 m. (16 ft. 5 in.) from the nearest rail. Crossings without barriers have cruciform signals as shewn in either figure 2 or in figure 3 depending on whether the line is single track or composed of several tracks.

In Bulgaria signals in the form of a St. Andrew's cross are established only at principal crossings which are not supervised, even if they were never supervised before. There are no crossings with only one signal for the two directions.

In Poland fixed cruciform signals must be placed at all unsupervised crossings, one signal at each side of the railway (fig. 4 and 5).

In Czechoslovakia the use of fixed signals (St. Andrew's cross shape) has recently been decided upon. There are no level crossings with a single fixed signal visible from the two directions of approach of the road.

In Turkey the State Railways do not yet use this type of signals.

The Smyrna - Cassaba Railway does not possess any signalling systems of this nature.

In Jugoslavia for the present, fixed signals of this form are placed only at crossings where supervision was abolished during the last few decades. There are also level crossings of lesser importance with only one signal visible from the two directions of approach of the road.

Question 2. — *Kindly state under what conditions the regulations allow level crossings to be left without supervision:*

a) *Those with good visibility for the users of the road;*

b) *Those not possessing satisfactory conditions of visibility.*

For Germany and Poland these conditions are dealt with in the replies to question I, 7.

In Bulgaria level crossings need not be supervised when they have a good visibility according to the Austrian regulations. Only those crossings on roads with light traffic are not supervised in spite of their inadequate visibility.

In Czechoslovakia according to the general regulations affecting secondary railway lines, barriers are not provided and crossings are not supervised.

In exceptional cases, which are always examined independently, decision is taken as to whether, having regard to the intense road traffic, it is necessary to protect (supervise) the level crossing naturally taking into account the important consideration — whether visibility conditions are favourable or not for the users of the road.

Signs at crossings without barriers.

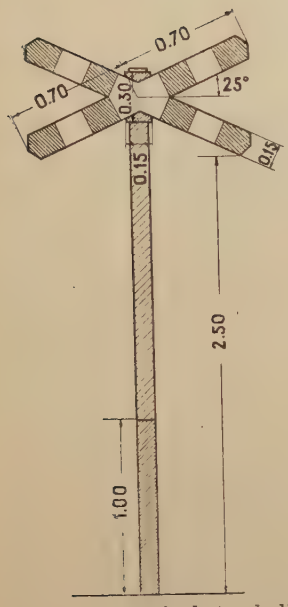

Fig. 4. — On single-track lines.

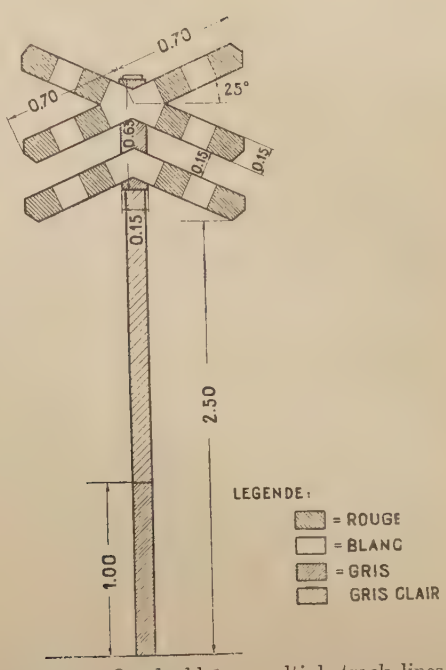

Fig. 5. — On double or multiple-track lines.

Note. — Rouge = Red. — Blanc = White. — Gris = Grey. — Gris clair = Light grey.

In Turkey, the State Railways have no rules on this subject.

The Smyrna-Cassaba Railway has also no fixed regulations in this respect. The arrangements regarding supervision or non-supervision at level crossings are decided for each case by a direct agreement between the State and the Management.

In Jugoslavia the regulations do not impose fixed conditions authorising level crossings to be left without supervision.

On the occasion of the preliminary negotiations for a concession, it is decided in agreement with the departmental and communal authorities which of the level crossings will be left without supervision.

Question 3. — *Kindly state the conditions under which the abolition of supervision is permitted :*

a) *The minimum distance along the road from which the train ought to be visible;*

b) *The distance of the train approaching the level crossing at the moment when it ought to be seen by the road users, when located at the distance stated under* (a).

According to notices published by the German railways the crossing is considered as properly visible if at least the following triangles of visibility are attainable (fig. 6).

a k d, visibility triangle for slow moving vehicles.

b k e, visibility triangle for fast moving vehicles.

a' k f, visibility triangle for pedestrians (at crossings reserved exclusively for pedestrians).

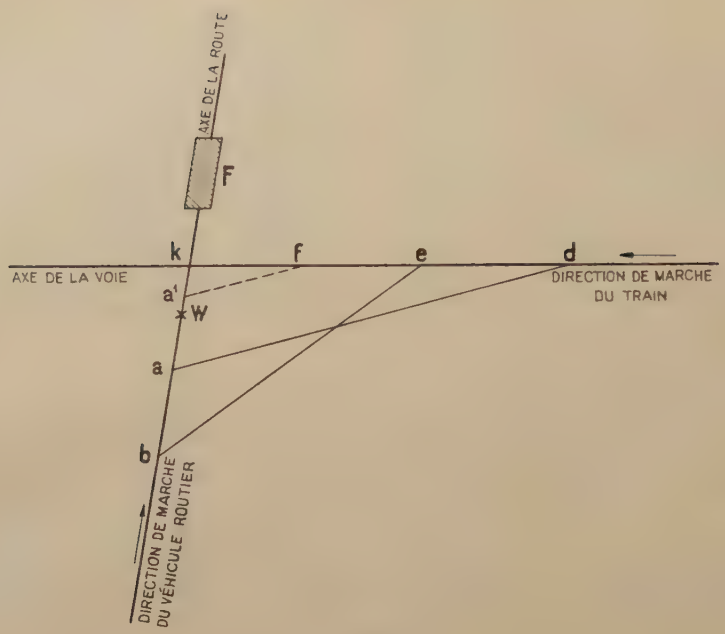

Fig. 6.

Explanation of French terms:

Axe de la route = Centre line of road. — Axe de la voie = Centre line of track. — Direction de marche du train = Running direction of train. — Direction de marche du véhicule routier = Running direction of road vehicle.

a and *b* are situated at 1.30 m. (4 ft. 3 3/16 in.) above the crown of the road.
d and *e* are situated at 1.50 m. (4 ft. 11 in.) above the head of the rail.
W k distance of the cruciform signal from the nearest rail (usually 5 m. = 16 ft. 5 in.).
a W = 3 m. (9 ft. 10 in.).
b W = 15 m. 49 ft. 2 in.).
a' k = 3 m. (or the nearest rail).
k d = 5 V in metres, where V represents the maximum permissible speed, in kilometres, at the crossing.
k e = 3 V.
k f = 2.5 V.

In Bulgaria the practice of the Austrian Federal Railways has served as the basis of the investigations carried out. It has been agreed to leave without protection those level crossings with sufficient visibility to conform with the conditions stipulated in the above-mentioned Austrian rules. The level crossings will be provided with protecting signals by virtue of the decisions of the International Union of Railways.

In Poland, approaching train and, at night the headlights of the locomotive, must be visible from the road along a length of 10 m. (32 ft. 9 1/2 in.) at least from the outer rail in both directions, during the whole period taken by the train to approach from a spot situated at a distance of L metres from the crossing.

The distance L is defined by the following dimensions :

a) For the crossing of a single track on lines of general importance L = 5.5 V-max.;

b) For the crossing of a single track on lines of local importance L= 5 V-max.;

c) For the crossing of two tracks, having a distance between their centres lines of 6 m. (19 ft. 8 in.), L = 7 V-max.;

d) For the crossing of two tracks having a distance between their centre lines of over 6 m. (19 ft. 8 1/4 in.), L = (5.5 + 0.25 *d*) V-max.

In the above particulars, V-max. represents the maximum permissible speed for trains on the line in question (in kilometres per hour).

In *Czechoslovakia* the minimum distance under *a*) is increased to 4 m. (13 ft. 1 1/2 in.). It is at this distance from the centre of the adjacent track that the warning cross (St. Andrew's) is erected.

So far as the question under *b*) is concerned, the following conditions have been decided upon.

The driver of the road vehicle, on the point of traversing the unsupervised crossing, ought to perceive the head of the train approaching the crossing in sufficient time to enable him to drive his vehicle across the so-called dangerous zone of the crossing, before the head of the approaching train has reached it. This zone extends to 2.50 m. (8 ft. 2 7/16 in.) on each side of the centre line of the track. On the basis of these conditions are determined the distances referred to under *b*), taking into consideration, on the one hand, the maximum speed of the trains running on the line, and on the other hand the maximum length of the road vehicles. These distances, based on the different categories of speed allowable on the Czechoslovakian Railways are comprised in the following table :

Maximum speed permitted in km. (*miles*) per hour.	Distance (b) on	
	local (secondary) lines.	main lines.
	Single track only.	
	metres (*feet*)	metres (*feet*)
40 (25) and less .	200 (*656*)	250 (*820*)
50 (*31*)	250 (*820*)	300 (*984*)
60 (*37.3*)	...	350 (*1148*)

For level crossings where there are several tracks the distance indicated in the above table is increased by as many times 50 m. (164 feet) as there are tracks crossed by the road. For intermediate speeds the distance entered for the next higher speed is taken.

In *Jugoslavia* the minimum distance along the road whence the train should be visible, depends on the speed of the trains and on the width of the dangerous zone. This zone extends to 5 m. (16 ft. 5 in.) on each side of the track; it forms, in consequence, a strip 10 m. (32 ft. 10 in.) wide for a single track. On crossings where there are several tracks, this width is increased by the distances between the tracks. It is necessary that pedestrians should perceive the train at a distance which makes it possible for them to cross the dangerous zone before the arrival of the train at the crossing.

Question 4. — *Kindly state whether in addition to the conditions laid down in paragraph 3, the visibility of the level crossing by the driver and his fireman is required.*

The visibility of the level crossing by the driver is not required either in Germany or in Poland. It is required in Bulgaria, Turkey and Jugoslavia. In Czechoslovakia the visibility of the level crossing by the driver and his fireman is considered desirable, but not absolutely necessary.

Germany communicates the following reasons to us : A good visibility is certainly desirable also for the driver, but it is not indispensable, for it is not of great help. If it is necessary that he should undertake measures for stopping the train, he ought to do it, when the automobile is still far from the crossing, and at that time the driver has no good reasons for supposing that he will stop at the crossing.

In Turkey the visibility of the level crossing by the driver is required at a distance of 200 m. (656 feet).

In *Jugoslavia* the legislative regulations

prescribe that posts should be erected to mark the place along the line where the driver must sound his whistle on approaching the level crossing, and that, when the visibility of the crossing by the driver does not exceed 25 m. (82 feet) on each side of the line. These posts are put at a distance of 500 m. (1 640 feet) on main lines and 200 m. (656 feet) on secondary lines.

Question 5. — *Please say if for crossings on roads carrying heavy mechanical traffic you require from the train a visibility to a point on the road further away from the track than that mentioned in § 3.*

The *German* reply is dealt with in § 3.

Poland. 1. Crossings on roads carrying automobile traffic, belonging to category I, ought to comply, according to the conditions of visibility mentioned above, with an additional requirement, notably, that the train, in covering the section of the track L′ = 3 V-max. in front of the level crossing, should be visible from every point on the road, along a length of 20 m. (65 ft. 7 in.) at least, on both sides of the outer rails.

For crossings having two tracks, the distance L′ increases beyond 0.075 *d* V-max.

2. For the computation of the distances L and L′ the speed V-max. is taken not below 40 km. (25 miles) per hour, even if the speed allowed on the line in question is less.

3. In special cases, when the maximum speed is not reached at the approach to crossings, the regional managements of the State Railways can fix, specially for this crossing, a visibility from the train conforming with the maximum actual speed at the approach to the crossing.

4. On lines used by trains with every axle braked, distances L and L′ may be reduced with the consent of the Ministry of Communications.

In Bulgaria the dimensions prescribed by the Austrian Federal Railways, in conformity with which the protection of level crossings will be regulated, allow a greater distance for lines which cross roads of greater traffic density.

The other systems do not require a visibility of the train at a greater distance, at level crossings, where there is heavy automobile traffic.

Question 6. — *Is the driver obliged to sound his whistle on approaching unsupervised level crossings or crossings in general, and do you consider that such a warning ensures sufficient safety to the road traffic at the crossing, particularly in view of the number of vehicles whose drivers are screened in ?*

The warning by whistle is not obligatory on the *Turkish* State Railways. *In Poland* it is obligatory only at unsupervised level crossings, of insufficient visibility, on lines of minor importance where there is no automatic installation for announcing the approach of trains.

In Czechoslovakia stringent regulations are in force.

Whistling is obligatory in Germany, at all unsupervised crossings; in Bulgaria at crossings where traffic is intense; on the Smyrna-Cassaba Railway (*Turkey*) at all crossings; in Jugoslavia at crossings which are hidden from the view of the driver.

Other particulars supplied are :

Germany. — The regulations E. B. B. O. prescribe that on the approach of the train to a crossing not provided with barriers, the bell of the locomotive should be sounded and this should be continued until beyond the crossing. Since the bell warning is often inadequate, intermittent whistling is insisted upon at the majority of crossings. It is true that motor drivers often assert that, when atmospheric conditions are unfavourable, the whistling of the locomotive, although strident, is not always audible; one is tempted, however, to regard this opinion in the light of an excuse.

Bulgaria. — At the approach to level

crossings with intense traffic, the driver is obliged to give the signal « attention » by means of a prolonged whistle signal. It will be appreciated that this signal is not altogether a sufficient measure of precaution for motor cars travelling at a high speed and above all, for those whose drivers are screened in.

Poland. — Under the new regulations, the driver must sound his whistle only at unsupervised crossings where the visibility is insufficient. Such crossings, in accordance with statutory requirements, are permissible only on lines where the speed of trains is not great (up to 50 km. [31 miles] per hour) and on roads having slight motor vehicle traffic. In consequence, this whistle is given at a comparatively short distance from the crossing (240 to 320 m. [787 to 1 050 feet] at most), and can always be heard there, which coupled with the obligation of stopping vehicles at the crossing (I, 3), ensures to a sufficient degree the safety of the traffic.

Czechoslovakia. — The driver is obliged to give a whistle signal at the approach to crossings which are not supervised or not closed by means of barriers, crossings which are not easily seen from the railway and which, for this reason, are equipped, at the distance given in *b*) of question No. 3, with warning posts.

At dangerous level crossings it has recently been decided that the driver must sound his whistle without interruption from the warning post to the level crossing. This precaution gives very good results. If the driver of the motor vehicle observes the caution necessary at an unsupervised level crossing, a whistling should provide sufficient warning of the coming of the train even when the driver is screened in.

Jugoslavia. — The driver must whistle on approaching a level crossing, when alongside the posts mentioned in question 4 and every time he sees a vehicle or a pedestrian approaching the crossing. This form of warning is considered sufficient for ensuring the safety of road traffic. As for motor cars whose drivers are enclosed, attention is drawn to the fact that level crossings on roads having intense automobile traffic are always provided with barriers.

Question 7. — *What are the distinguishing features of the signals mentioned in § 1, at level crossings having two or several tracks ?*

Germany, Poland, Czechoslovakia and Jugoslavia have adopted double crosses for level crossings of two or more tracks.

In Poland the lower arms of the St. Andrew's cross are doubled (see fig. 5) where these are placed at crossings with two tracks. On lines having three or more main tracks, all the crossing must be supervised.

In Czechoslovakia at crossings on secondary roads, signals of a small size are used and on important highways signals of a large zize.

Question 8. — *Do the signals mentioned in § 1 change their indications at crossings periodically supervised and, if so, in what manner ?*

In Germany the signals do not shew whether the crossing is supervised or not but only whether it is provided with barriers. As temporary supervision of barriers is not adopted, those crossings which are periodically supervised are without barriers. These have always the same signals as crossings without barriers. Consequently, signals of changeable indication do not enter into consideration.

In Bulgaria, Poland, Czechoslovakia and Jugoslavia the signals do not change their indication at level crossings which are periodically supervised.

D. — General information.

Question 1. — *Of what colour are the barriers painted; of what colour are the fixed signals on the barriers and signals at level crossings ? How do you comply*

in this respect with decisions of the U. I. C. as regards the colour of the triangular signals, recommended by the International Convention of 1926 ?

The horizontal rails of the barriers and the signals at level crossings (warning crosses) are painted in black and white in Czechoslovakia and in Jugoslavia. On the other systems they are painted in red and white.

In Poland the rails of the barriers are painted in white colour, the intermediate part being in white and red. Signals at unsupervised crossings are likewise painted in white and red.

In Germany optical signals for automobile traffic have the same colours (white centre with red border). The observations made have shewn that white and red are more clearly seen from afar than other combinations of colours. White shews up well on a light background; red when well maintained is equally well seen on a light background as on a dark one.

The *Czechoslovakian Rys.* notify us that they cannot comply with the decisions of the U. I. C. so far as the uniform shape of the triangular signals is concerned, on account of the fact that these signals were previously selected by the Autoclub of the Czechoslovakian Republic.

No replies are forthcoming from the other Systems on this matter.

Question 2. — *On what level crossings are the barriers illuminated ?*

In Germany the barriers are illuminated only at crossings having considerable traffic.

The standard type of lighting employed is that of reflectors (Tiefstrahler) placed at the sides; they illuminate the rails of the barriers to a height of 2.50 m. (8 ft. 2 7/16 in.) without dazzling either the driver or the users of the road.

In Bulgaria it is only level crossings in the towns which are illuminated.

In Poland the following crossings must be illuminated :

a) Crossings whose barriers are controlled on the spot, if the road traffic is considerable;

b) Crossings having barriers normally closed;

c) Crossings having barriers controlled from a distance.

On other closed crossings, all the time that the barriers are lowered at night time, a gatekeeper must be present with a lantern in his hand.

Czechoslovakia does not possess any barriers which are flood lighted.

On the *Turkish State Railways* it is a general rule to illuminate all the barriers at level crossings; on the *Smyrna-Cassaba* Railway they are not illuminated.

In Jugoslavia the only barriers which are illuminated are a few with intense motor traffic in the suburbs of big towns.

Question 3. — *Kindly say if you consider it useful to improve visibility, during the night, of barriers, signals, etc., by means of special devices (surfaces reflecting motor car head lights, red lenses, etc.) ?*

Germany and *Poland* do not find this to be necessary.

Czechoslovakia and *Jugoslavia* are in favour of the practice.

Turkey (State Railways) finds it to be useful, but has not had any experience of its use.

In particular the following opinions are advanced.

In Germany devices for reflecting light at barriers are not considered to be either necessary or even useful. When they are well maintained the rails of the barriers, painted in white and red, reflect the rays of light sufficiently.

It is not possible to adopt special devices for reflecting the light instead of illuminating the barriers, since the crossings are used equally by ordinary vehicles which are not fitted with head lights.

Snow and dust diminish the efficiency of light reflecting devices.

On curves they are perceived very much later than the floodlighting direct-

ed from above the barriers, and which indicate the presence of the crossing.

In Poland such devices do not seem necessary for motor cars, whose head lights illuminate sufficiently all the signs which come into their range. In the case of horse drawn vehicles having feeble lights, these reflecting signs may easily cause misunderstanding.

In Czechoslovakia the improvement of the visibility of barriers by means of red glasses, reflecting the light from the head lamps of automobiles has been practised for some time and is considered to be advantageous. The illumination of barriers and signals by means of artificial lighting is not recommended.

In Jugoslavia it is considered useful to improve the visibility of barriers and signals at night time. Trials have already been made with red lenses reflecting the light from the head lamps of automobiles. It is proposed to apply them to barriers and also to signals at level crossings.

Question 4. — *What is the maximum number of trains and of road vehicles at existing level crossings. (Kindly give several typical examples.)*

According to the statistical information received in reply to this question, observations have been made of the maximum flow of road and rail traffic at level crossings.

Country.	Number of trains daily. (*a*).	Period of observations, hours.	Observed number of		Approx. number of vehicles in 24 hours. (*b*).	Product of (*a*) × (*b*).
			pedestrians and bicycles.	vehicles.		
Poland	224	1	750	190	1900	430 000
Czechoslovakia	165	...	...	. .	3500	580 000
Poland	124	12	...	4396	5000	620 000
—	120	1	...	432	4300	520 000
Germany	112	14	5481	4719	6000	670 000
—	105	14	3983	3980	5000	530 000
—	83	24	8969	5989	6000	500 000

See also on pages 1314 and 1315 the figures for the United States of America.

Note on the protection of level crossings according to data published by the American Railway Engineering Association and the American Railway Association.

In the countries comprised in the present report, automobile traffic, whose effect on the means of protection of level crossings forms the subject of this enquiry, is of varying intensity; there are also several countries where automobiles are little used. In order to verify the accuracy of the conclusions drawn from the replies obtained, I have checked them by making a comparison under this head, with the particulars coming from the United States, a country where automobiles are in very considerable use.

The railway systems of the U. S. A. possess 250 000 level crossings. The methods of protecting these crossings are set down in the following table, prepared by 53 large Railway Companies for the Interstate Commerce Commission, in 1925.

This table comprises 177 813 level crossings.

Barriers in operation:

During 24 hours	1.5 %
Less than 24 hours	1.3 %
Total	2.8 %

Gatekeepers only or with means of protection other than barriers:		Audible and optical signals	2.3 %
		Audible	2.5 %
Keepers working 24 hours	0.6 %	Optical	0.7 %
Keepers working less than 24 houres	2.9 %	Total.	5.5 %
Total	3.5 %	Warning signals	88.2 %

The tendencies towards a gradual change in the methods of protecting the level crossings are evidenced by the following classification :

	1925	*1926*	*1927*	
Barriers	6 386	6 170	5 957	2.5 %
Supervised	7 935	7 765	7 554	3.2 %
Signalling systems	12 964	13 992	15 213	6.5 %
Fixed warning signals	202 348	202 620	203 817	86.2 %
Other unsupervised crossings.	4 068	4 611	3 742	1.6 %
Total.	233 701	235 158	236 283	100 %

The above figures shew that the number of level crossings provided with barriers is diminishing yearly; the same thing is happening as regards supervision without barriers. On the other hand, the number of level crossings having automatic signalling for announcing the approach of the train and the number of crossings having only fixed warning signals are gradually increasing.

A disturbing factor for the railway administrations is the fact that, during the years in question, the total number of level crossings shews a steady increase, in spite of a certain number of crossings having been replaced by over- or underline bridges.

Also, in interested and competent circles, the idea is being brought to light that it is necessary to prevent, by regulations, the building of new level crossings.

Moreover, experience shews us that according as road traffic becomes mechanised, the number of vehicles at many level crossings diminishes greatly. Motor vehicles travelling at high speed prefer the best route rather than the shortest. That is why crossings on secondary roads are often abandoned in favour of main roads having a superior surface and greater importance for traffic. At the present time, the roads are not controlled by a central authority, but by nearly 150 000 local administrations having an autonomous character. This system excludes all uniformity in the consideration of schemes and in methods of construction, also in methods of signalling at crossings and the sharing of the costs for the protection of crossings or their replacement by under- or overline bridges.

According to competent observers, an endeavour should be made to draw up a general uniform scheme for main roads and others of a certain importance, including a good system for protecting crossings or the construction of over- or underbridges at the busiest places. Likewise an effort should be made to abolish, if possible, crossings of secondary roads having little traffic and railways, and to divert these roads to crossings with a good signalling system, as mentioned above, or to over- or underbridges, built at the point of intersection, with the railway, of several converging roads.

Before the development of motor traffic and in the early years of its evolution, pressure was brought to bear on the railway authorities by competent bodies to induce them to speed up the construction of over- and underbridges, but at present this tendency is diminishing. It has been appreciated that the principal

cause of the trouble is that it is not the railway but the motor vehicle which ought to shoulder the burden of a considerable part of the costs of reconstruction, and these costs reach fabulous sums.

According to the *Bulletin of the American Railway Engineering Association*, No. 292, p. 280, the cost of replacing 250 000 level crossings by over- or underbridges would amount to 12 billions of dollars, which represents 50 % to 75 % of the total value of the whole system of railways. According to *American Railway Signaling Principles and Practices*, Chapter XXIII, a pamphlet issued by the American Railway Association, Signal Section [see also *Bulletin of the International Railway Congress*, 1929, vol. 11, p. 551], 3 240 level crossings have been converted into over- or under bridges during the period 1921-1924, involving an expenditure of 194 millions of dollars and representing an average cost of 60 000 dollars for each crossing.

Moreover, the record of accidents shews us that the most dangerous moment for motor traffic is not when it is going over the railway at a level crossing, but rather when it is traversing the intersection of two roads.

Here are some statistical particulars concerning accidents: in 1925 there were 47 128 automobile accidents in the State of New York, of these 148 only, that is to say 0.3 % took place at level crossings.

Robert H. Ford says, in *Bulletin* 298 *of the American Railway Engineering Association*, that in 1926 there were in the United States 600 000 injured and 20 819 killed in accidents on roads and at the crossings of two roads, whilst there were in the same time 6 991 injured and 2 494 killed at level crossings on railways, that is to say 1.5 % of the total number. In spite of the diversity which reigns in the administration of the roads, directed by 150 000 authorities, recently the conviction has taken growth (it is not yet the general rule) that it is just that the Treasury of the Federation and the individual States should participate in the costs of replacing level crossings by over- or underbridges, as well as in those of their improved and perfected protection. The share of these authorities now reaches an average of 50 %, varying in different States from 10 % to 100 %.

The Railways, on their side, propose the following division of the costs of replacing level crossings by over- or underbridges : 50 % by the General Treasury and 50 % by the finances of the State and the Railway Administration, depending on local conditions.

Bulletin 292 *of the American Railway Engineering Association* contains statistics of traffic on a considerable number of crossings of roads with the railway in the State of New York, in 1925. These figures shew the number of vehicles in 24 hours, the number of trains, the product of the two and the methods of protecting level crossings.

Crossings provided only with fixed signals, have a mean product of 47 298; in particular cases it reaches 185 000. The number of trains reaches 59, the number of vehicles 6 217 daily.

In places where there are optical signals, the mean product reaches 68 261; the number of trains does not exceed the figure given above.

For crossings fitted with barriers, the mean product reaches 360 597, rising to 803 114; the number of trains, except in a few special cases, is more than 100 for the 24 hours and attains 371; the number of vehicles varies between 1 200 and 6 400 for the 24 hours.

The American Railway Engineering Association contemplates, at present, the standardisation and improvement of the signalling at crossings, and above all automatic signalling (flash-light and wig-wag).

The standards of visibility at level crossings have not yet been settled.

Traffic on the level crossings in the State of New York, in 1925

Average daily traffic.		Product $a \times b$.	Average daily traffic.		Product $a \times b$.
Road.	Railway.		Road.	Railway.	
a	b		a	b	
Barriers.			**Supervised.**		
1581	20	31 620	3082	27	83 214
1765	142	250 630	1713	44	75 372
2829	211	596 919	1509	27	40 743
1042	114	118 788	3533	32	113 056
6348	22	139 656	7097	31	220 007
1969	129	254 001	4303	75	322 725
1681	64	107 584	3605	40	144 200
2063	371	765 373	1328	13	17 264
4884	154	752 186	1562	35	54 670
1174	125	146 750	1714	23	39 422
2686	299	803 114	2315	17	39 355
		Total : 3 966 621	1710	122	208 620
					Total : 1 358 648
Average of 11 crossings : 360 597.			Average of 12 crossings : 113 221.		
Optical signals.			**Optical and audible signals.**		
932	58	54 056	1498	49	73 402
3980	14	55 720	3177	18	57 186
4723	13	61 399	3877	27	104 679
1960	8	15 680	1317	13	17 121
3412	54	184 248	997	46	45 862
3490	19	66 310	611	25	15 275
4218	21	88 578	377	25	14 425
5079	21	106 659	2456	48	117 888
595	13	7 735	2111	20	42 220
1362	31	42 222	694	13	9 022
		Total : 682 607			Total : 497 080
Average of 10 crossings : 68 261.			Average of 10 crossings : 49 708.		

Average daily traffic.		Product $a \times b$.
Road.	Railway.	
a	b	
Audible signals.		
4607	53	244 171
1359	11	14 949
1109	26	28 834
6515	1	6 515
4483	9	40 347
1555	15	22 725
511	7	3 577
1241	22	27 302
	Total :	388 420
Average of 8 crossings : 48 553.		
Fixed signals.		
1781	25	44 525
1769	13	22 997
3053	9	27 477
2385	16	38 160
6056	6	36 336
4648	40	185 920
740	22	16 280
2278	3	6 834
2352	24	56 448
2291	54	123 714
6217	5	31 085
2155	16	34 480
3154	31	97 774
2690	8	21 520
1642	24	39 408
1177	7	8 239
1153	11	12 705
2607	15	39 105
1241	28	34 748
2072	59	122 248
934	29	27 086
1852	33	61 116
1635	35	57 225
3676	8	29 408
183	5	915
2625	27	70 875
1484	58	86 072
2575	4	10 300
494	58	28 652
		Total : 1 371 652
Average of 29 crossings : 47 298.		

Recapitulation.

(The figures appearing below represent the product of the mean road traffic in 24 hours and the mean daily traffic on the railway.)

Barriers, average of 11 crossings	360 597
Supervised crossings, average of 12	113 221
Optical signals, average of 10 crossings	68 261
Optical and audible signals, average of 10 crossings	49 708
Audible signals, average of 8 crossings	48 553
Fixed signals, average of 29 crossings	47 298

Summary.

CHAPTER I. — *Laws and agreements.*

Questions 1 to 5. — The replies received on the subject of the matters treated in the first five questions of the enquiry cause us to believe that it would be desirable to make further efforts to standardise warning signals on roads at level crossings in respect of shape, colour and distance from the railway, and also that it would be useful to fix a uniform code of rules for the traffic on the roads.

It would be necessary to recommend the publication of regulations concerning : — warning signals on roads with intense motor traffic, in agreement with the International Convention of 1926, fixed signals at level crossings of the type adopted by the U. I. C. ; finally the compulsory slowing up of vehicles at all unsupervised level crossings, with the obligation to stop in case of insufficient visibility at unsupervised crossings without automatic signalling. This obligation to stop completely ought to be brought to the notice of road users by means of a notice of standard form on the fixed warning signal (or cross) which is set up at the level crossing.

It is necessary to require a standstill of the vehicles at the crossings by analogy with the customary practice in towns where signalling does not exist. When a vehicle emerges from a side street with the object of crossing a main road, in order that the driver may take his bearings he reduces his speed to a minimum or even stops, even if there exists no formal order to this effect.

The railway cannot remain behindhand in this respect by comparison with the main avenues of communication in the cities.

The protection of level crossings ought to be based on the regulations appertaining to all descriptions of railways, except those lines of the nature of tramways.

Question 6. — The construction of over- and under crossings to replace level crossings ought to be examined from a point of view other than the habitual one. With the means of signalling the approach of trains, which have been adopted within recent years, the level crossing should be regarded solely as a place on the road, where the progress of the traffic is more difficult, and not as a place more dangerous than the crossing of two roads where the traffic is more intense. It would, consequently, be necessary to base the decision as to the construction of over- or under crossings (bridges) on a financial calculation which would take into account the approximate capitalised value of the losses resulting from delay to road traffic due to vehicles waiting for the train to pass, in comparison with the cost of abolishing the level crossing, less the saving in signalling or protecting the crossing.

From a consideration of the aforementioned statistics relating to the State of New York, I believe that the question of the substitution of over- and under crossings for level crossings may be considered as definitely worth while if the number of trains for the 24 hours exceeds 400, or if the result of the multiplication

of the number of trains and the number of vehicles per day exceeds 800 000, where the number of trains exceeds 100 in 24 hours :

Question 7. — In consequence of the replies obtained and the facts quoted above, I suggest the following classification of level crossings.

I. Unsupervised crossings without barriers and without automatic signalling on the approach of the train.

II. Unsupervised crossings, without barriers but with automatic signalling.

III. Crossings with barriers, operated on the spot or from a distance.

Category I may be applied when the visibility is sufficient and when the number of trains does not exceed 100 in 24 hours or if the product of the number of trains and the number of vehicles in 24 hours is not greater than 70 000 (see p. 1314).

Category II will comprise crossings having insufficient visibility and when the traffic does not exceed the prescribed intensity.

To category III will belong all crossings having traffic of greater intensity than that referred to above and of less intensity that that referred to in the above § 6.

Moreover, in category I may be classed those crossings with insufficient visibility, on lines where the speed of trains does not exceed 50 km. (31 miles), if notwithstanding the circulation of vehicles does not exceed 150 in 24 hours.

Question 8. — On the subject of visibility at level crossings it should be remarked that in certain countries, legislation ordains the possibility of obtaining and maintaining visibility ; in some others, there are restrictions only as to the construction of buildings, but which do not affect for instance, trees ; in others, action may only be taken on the right of purchasing.

As will be realised from the report, visibility is indispensable and more important, more efficacious even than supervised barriers. It would consequently be desirable to obtain several changes in the legislation in order that visibility, such as the prescriptions require, may be assured.

Question 9. — As to the question of fencing for closing the railway along a certain length near the crossing, the replies do not demonstrate either precise advantages or indispensable necessity for such barriers, and on this subject there are no observations to be made.

Question 10. — The division of the costs of the provision and maintenance of the various kinds of protection, occasioned by the increase of road traffic, is not treated uniformly.

From the more definite replies it appears that the railway ought not to participate in the cost of the provision and maintenance of the crossing, if the supervision or signalling are necessitated by the construction or improvement of the road.

If it were necessary as a result of the increase of the traffic on the road, to replace a level crossing by an over or under crossing, the railway might share the cost, but only in proportion to the expense for supervision and maintenance which it had incurred up to that time.

Question 11. — The regulations which control the supervision of level crossings are posted at stations in some countries ; in other countries they are exhibited at the crossings, and in still other countries there is no fixed procedure under this head.

It seems advantageous to include these regulations in the instructions for drivers of automobiles and also to bring them to the knowledge of the public by official means, with any amendments which may be introduced.

It would be necessary to make an ex-

ception for the regulation requiring the stopping of a vehicle at the crossing, where it would be found indispensable.

This regulation would be displayed well in evidence on a post or a warning signal at the level crossing.

CHAPTER II. — *Statistics.*

Question 1. — The percentage of unsupervised crossings is the following :

Germany	55 %
Bulgaria	79 %
Poland	67 %
Czechoslovakia	95 %
Turkey (State Rys.)	64 %
Id. (Smyrna-Cassaba Ry.)	94 %
Jugoslavia	71 %

(76 % on narrow gauge lines.)

These figures shew that supervision of the crossings is much more widespread in the above countries than in the United States where the number of crossings, either having automatic signalling or furnished only with fixed signals, amounts to 92.7 %, although the intensity of automobile traffic on the road is very much greater. The conclusion to be drawn is that it is necessary to increase the efforts to replace supervision by automatic signalling systems or fixed signals.

Question 2. — The percentage shewn in the report of over- or under crossings to level crossings is as follows :

Germany	3.3 %
Bulgaria	1.2 %
Poland	5.9 %
Czechoslavakia	1.1 %
Jugoslavia	2.3 %

Question 3. — In the replies received on the subject of accidents at crossings, several characteristic features present themselves ; they are as follows :

In Germany, 47 % of the serious accidents occur at crossings provided with barriers ; they are caused by the collision of automobiles with the barriers or by the fault or drivers who open them on their own responsibility.

In Czechoslovakia, the number of collisions of motors with closed barriers was nearly 5 times those of trains with motors, and 84 % of the total motor car accidents, or 60 % of accidents in general at level crossings are collisions with closed barriers.

These figures demonstrate the more than doubtful efficacy of the method of protecting, by means of barriers, those crossings which have an intense and high-speed flow of automobile traffic.

Question 4. — From the replies of the countries which intimate the number of over- and under crossings built since 1926, it appears that this number represents 1/840 of the total of road crossings on railways.

CHAPTER III. — *Protection of level crossings.*

A. — *Supervision.*

Question 1. — The Railways who have replied to the Questionnaire make use of supervision without barriers only in exceptional cases. In the United States of America, nearly 3 % of the crossings are supervised under these conditions and this number is diminishing year by year.

Question 2. — None of the replies notify the use of barriers automatically closed by the train. In the United States installations of this nature are being examined (*Bulletin* 329, 1930, A. R. E. A.).

Question 3. — Warning crosses of special type (cf. fig. 1) are used at level crossings having barriers, solely by the German lines.

This form of supervision is a question to be discussed.

Question 4. — An increased visibility

of the barriers is obtained by painting them in white and red or white and black stripes, by using red or orange coloured lights, red reflecting lenses, or by a general illumination of the level crossing, if the traffic is intense. As is provided by the statistics of accidents caused by collisions of motor cars with closed barriers, the latter barriers do not attain their object in the majority of cases ; the conclusion might then be drawn that it is advisable to abandon the methods which are the most troublesome and costly, lamps in particular, and merely to paint the barriers in coloured stripes, to fit them with reflecting lenses and in cases where the traffic is very great, to endeavour to illuminate the crossing in an effective manner.

Question 5. — It should be accepted as obligatory, for closing the barriers, the moment which precedes the passage of the train by two minutes, for it is the minimum adopted by the countries which have sent in replies and which consider this interval to be sufficient. It does not appear from the replies received that signalling the departure of the train from the previous station by means of bells can give any evident advantages. At crossings having telephonic communication it would be useful to warm the keeper, by telephone, of any delay to the train exceeding 10 minutes.

If the tendency is accepted, which is predominant in the State of New York and which consists of only using barriers on lines of heavy train traffic (above 100 daily), it will be necessary to depend above all on the vigilance of the gatekeepers, if, perchance, they are not warned of the coming of the train by automatic bells.

Question 6. — According to replies received, normally closed-barriers which are opened to allow road traffic to pass are in use only on lines of light traffic (Germany), or at level crossings having light road traffic but considerable railway traffic (Poland) ; finally barriers are kept normally shut at crossings on private roads.

Question 7. — In all countries use is made principally of barriers pivoting on a horizontal axis.

Question 8. — The two barriers of a crossing are put into action simultaneously by a single mechanism in Germany, Poland, Czechoslovakia, Turkey (State Rys.) and Jugoslavia as a general rule. The contrary is the case in Bulgaria and on the Smyrna-Cassaba Railway (Turkey). The first system is to be devised, except at long crossings and where heavy traffic does not cease, to allow for the fact that it is not always possible to close the two barriers simultaneously.

Question 9. — According to the replies received the distance from the barrier to the centre of the adjacent track may be fixed at 3 m. (9 ft. 10 in.) as a general rule, and at 8 m. (26 ft. 3 in.) for barriers operated from a distance of :

1. Less than 50 m. (164 feet) if the barriers are not clearly visible from the control post;
2. More than 50 m. if they are not clearly visible from the control point and have not ringing apparatus of sufficient duration to enable the crossing to be traversed.

Question 10. — The maximum distance of the gatekeeper's cabin from barriers operated at a distance may attain 1 500 m. (4 920 feet); a maximum of 4 barriers are set into motion by the same gearing; visibility of these barriers from the control post is required only in Germany.

Question 11. — Barriers operated at a distance are in general provided with bells for warning pedestrians and vehicles that they are about to be closed. In Poland, the bells are not essential if the barriers are clearly visible from the control post. In Germany and in Tur-

key (State Rys.) pedestrians finding themselves enclosed between the barriers can open them themselves.

B. — *Automatic signalling of trains at level crossings.*

Question 1. — Automatic devices warning the public of the approach of a train to the level crossing exist only in Germany, in Poland and in Jugoslavia, for the purpose of experiment only and in limited numbers.

Question 2. — This experiment has given such good results in Germany and in Poland, that it is proposed to introduce automatic signalling appliances in much greater numbers. The opinion is held that this system of signalling can replace barriers and supervision, offering, in addition, the great advantage that it does not hold up traffic on the roads beyond what is strictly necessary.

The development of this form of protection in the United States indicates to us that its application will be extensive. There is no better substitute for it at crossings where the visibility of the approaching train is not sufficient.

Question 3. — According to the replies received the automatic signal ought to start to function 30 seconds before the arrival of the fastest train at the crossing. It is required in Poland and Switzerland that the signal should continue to function until the last wagon of the train has left the level crossing.

No country has experimented with signals functioning for a pre-determined period before the arrival of the train, taking into account the variable speeds of the trains.

Question 4. — It is only in Germany that standards have been fixed for optical signalling. As a general rule a white light flashing about 40 times a minute is shewn; as the train approaches the white light is masked by a red lens and flashes twice as quickly. The Swiss regulations likewise require 80 flashes per minute of red light. It is the same in Poland. The United States have no fixed standard in this respect.

According to the American Railway Association at places where the number of foot passengers is great, notably near schools, the use of bells (audible signals) as adjuncts to the optical signals and with the sole object of warning pedestrians, is justified in certain cases. It is not necessary that the ringing should be so loud as to annoy the occupiers of nearby premises.

In order to ensure uniformity of these signals in the future, it would be worthy of recommendation that the German standards should be adopted.

Question 5. — The appliances already in use are fed with current from the local mains, from a local battery, or with acetylene. The control apparatus is energised by current from accumulators.

Question 6. — At level crossings furnished with appliances for signalling the approach of trains (in Germany and in Poland), fixed signals are placed above these (see III, C 1), as at unsupervised crossings where the approach of trains is not signalled. In Switzerland these are not made use of, neither are they in the United States, but the automatic appliances are provided with similar fixed crosses.

This latter method seems to be the most suitable and the best for adoption as general practice (fig. 8).

Question 7. — In case of the breakdown of the automatic apparatus signalling the approach of trains, the level crossing is supervised temporarily.

C. — *Arrangements enabling road users to inform themselves of the approach of trains.*

Question 1. — The provision of fixed signals of the shape of a St. Andrew's

cross is obligatory at all unsupervised level crossings in Poland and in Czechoslovakia. In the other countries they are provided only at principal crossings or at those where supervision has recently been withdrawn. In Germany the use of these signals is not obligatory at little frequented and easily visible crossings. In Turkey (State Rys.) they are not used. In the United States it has been found useful to place St. Andrew's cross signals at all crossings. It appears, therefore, insufficient to place them, in conformity with the prescriptions of the U. I. C., solely at crossings where supervision has been recently withdrawn. The crosses may be superfluous at places where there is an automatic signalling appliance, surmounted by a cross, and finally at all crossings on lines where the speed does not exceed 15 km. (9.3 miles).

The conclusion is to be drawn that these signals should be installed, in the first instance, on all roads of international importance, next on all routes carrying automobile traffic and finally at all crossings on less frequented roads where the regulations require them (fig. 4).

Question 2. — The majority of the States interrogated have no precise regulations for permitting level crossings to be left without supervision.

In Bulgaria all crossings of good visibility are unguarded; in Czechoslovakia only crossings on secondary lines are left without supervision; as regards crossings which have not good visibility, they may remain without supervision only if the traffic is slight. In Germany, in accordance with the regulations E. B. B. O. only crossings on secondary lines may be left without supervision, under the following conditions :

1. Crossings with heavy road traffic, good visibility, speed of trains not more than 15 km. (9.3 miles);

2. Crossings with light road traffic, without regard to visibility, speed of trains not more than 40 km. (25 miles).

In Poland the regulations do not require that crossings should be supervised, if the total number of trains, in 24 hours, and of vehicles in the two directions at the time of greatest activity on the road does not exceed 200. Automatic signalling should be applicable to unsupervised crossings, fulfilling the standards cited above, if visibility is insufficient, with the exception of crossings where the road traffic is not over 150 units in 24 hours, where the automobile traffic is exceptional and where there is no appreciable permanent motor bus traffic, if, nevertheless, the speed of trains does not exceed 50 km. (31 miles) per hour.

For these crossings as well as for all clearly visible crossings, with less intense traffic than above mentioned

$$\left(\frac{\text{number of trains}}{24 \text{ hours}} + \frac{\text{number of vehicles}}{1 \text{ hour}} \leqslant 200\right),$$

fixed signals are considered adequate.

As I said in Chapter I, 7, I would be inclined to propose the Polish standards, but with the substitution of the figure 200, which stipulates supervision by the following condition : crossings may be left without supervision when visibility is good and they must be provided with automatic signalling if the visibility is defective, when the traffic does not exceed 100 trains in 24 hours, or when the product of the number of trains and the number of vehicles in 24 hours is not greater than 70 000.

This standard is founded on experience gained in the United States, where the question has been under investigation. The minimum limit of 150 vehicles in 24 hours might be retained, thus permitting a crossing of bad visibility to be

left without supervision if the speed of trains does not exceed 50 km. (31 miles) per hour.

Question 3. — In Germany and in Poland the conditions of visibility allowing the absence of supervision are nearly similar, in Czechoslovakia they are slightly different. Since question C 5 treats of a similar matter, I am dealing with the two points 3) and 5) together (see the replies of Poland to question C 5). The distance between the outer rail and the place on the road whence the train should be visible is determined as follows :

	Slow moving traffic.	High speed traffic.	Pedestrians.
Germany	8 m. (*26 ft. 3 in.*)	20 m. (*65 ft. 8 in.*)	3 m. (*9 ft. 10 in.*)
Poland	10 m. (*32 ft. 9 in.*)	20 m. (*65 ft. 8 in.*)	3 m. (*9 ft. 10 in.*)
Czechoslovakia . .	4 m. (*13 ft. 1 1|2 in.*)	4 m. (*13 ft. 1 1|2 in.*)	4 m. (*13 ft. 1 1|2 in.*)

I think that the German dimensions may well be adopted.
The distances L, from which the train should be visible, are the following :

		Slow moving road vehicles.	High speed road traffic (automobiles).	Pedestrians.	
Germany. . .		L = 5 V	L = 3 V	L = 2.5 V	V = maximum permissible speed in km. at level crossings.
Poland.	For lines of general importance.	L = 5.5 V max.	L. = (3 + 0.075 *d*) V max. L. = 2.5 V. max.		V max. denotes the maximum speed of trains. *d* = distance between the centres of tracks.
	For lines of local importance.	L = 5 V max.			
	For double-track lines.	L = (5.5 + 0.25 *d*) V max. L = 7 V max (for *d* ⩽ 6 m.)			

		For fast lines.	Secondary lines.	Main lines.
Czechoslovakia.	V ⩽ 40 km.	200 m. = 5 V	250 m. = 5 V + 50
	V ⩽ 50 km.	250 m. = 5 V	300 m. = 5 V + 50
	V ⩽ 60 km.	...	350 m. = 5 V + 50

I suppose the following standards could be accepted :

For slow speed vehicles.

$$L = (5 + 0.25\ d)\ V \text{ max.}$$

For high speed vehicles.

$$L = (3 + 0.075\ d)\ V \text{ max.}$$

from which the following visibility triangles might be deduced (for motor vehicles in intersected line and for horse drawn vehicles in continuous line), fig. 7 :

K *a* = 8 m. (26 ft. 3 in.)
K *d* = L = (5 + 0.25 *d*) V,
k *b* = 20 m. (65 ft. 8 in.)
k *c* = L = (3 + 0.075 *d*) V,

wherein *d* denotes the distance between the centres of outside tracks, V denotes the maximum speed of trains at the particular crossing (usually V maximum permissible on the line).

In admitting here the real speeds actually attained at a particular crossing, I am being guided by the new Polish regulations (see replies § 3 to question C 5).

Question 4. — The visibility of the level crossing by the driver is not required either in Germany or in Poland. In Czechoslovakia the visibility of the crossing by the driver and his assistant is considered desirable, but not absolu-

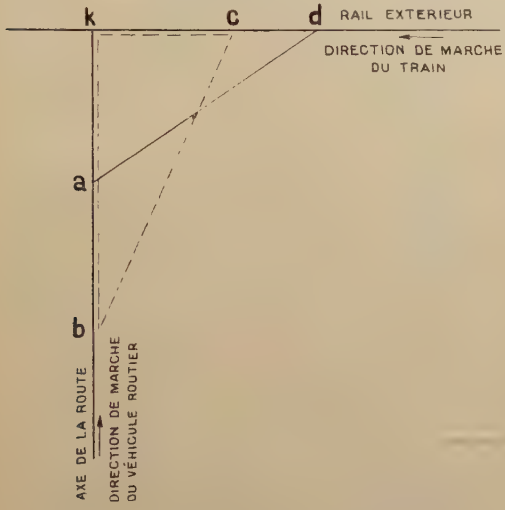

Fig. 7. — Proposed visibility triangles at level crossings.

Explanation of French terms:

Axe de la route = Centre line of road. — Direction de marche du véhicule routier = Running direction of road vehicle. — Direction de marche du train = Running direction of train. — Rail extérieur = Outer rail.

tely necessary. Taking into consideration the circumstance that daytime visibility may disappear during the night, for the motor vehicles are not lighted at the sides, I am of the opinion that a visibility of the train from the road which would give the triangles proposed in the preceding paragraph should be regarded as sufficient.

Question 5. — The remarks concerning the visibility of the train from a more

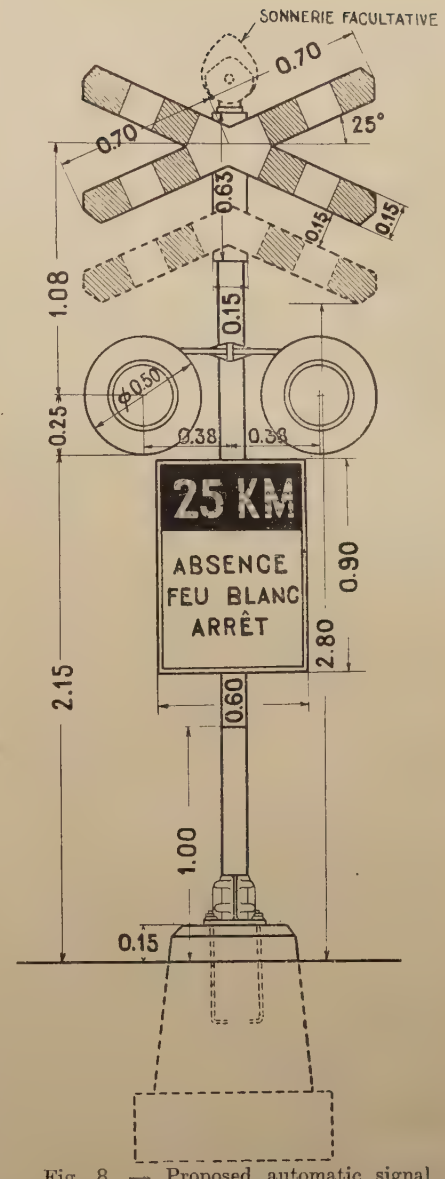

Fig. 8. — Proposed automatic signal with flashing lights.

Note. — The figure 25 km. is to be taken as an example only and may be altered to suit the needs of each country.

Explanation of French terms:

Sonnerie facultative = Optional bell. — Absence, feu blanc, arrêt = Stop if white light is not shown.

distant point along the road, on account of the intensity of automobile traffic, are already contained in § 3.

Question 6. — The sounding of the whistle by the driver at the approach to level crossings is not obligatory in Turkey (State Rys); on the Smyrna-Cassaba Railway it is required at all crossings.

In Poland it is obligatory only at unsupervised crossings of insufficient visibility, on lines of lesser importance where there is no automatic signalling on the approach of the train.

In Czechoslovakia the requirements are of a very similar nature.

Whistling is obligatory in Germany at all unsupervised level crossings; in Bulgaria at crossings with heavy traffic; in Jugoslavia at crossings invisible to the driver.

In the United States, difficulties have recently arisen in the States which require warning whistling at a distance of 400 m. (1 312 feet). These difficulties are occasioned by the variability of the speed of trains as well as by the very diverse speeds, of horse and mechanically propelled vehicles. This prompts the view that it would be useful to sound the whistle at two places and to replace the ordinary whistles by sirens.

I consider it will be necessary to limit the use of whistles to unsupervised crossings which are dangerous by absence of visibility and have no automatic signalling.

Question 7. — At crossings having two or more tracks the fixed signals mentioned in § 1, have double crosses in Germany, in Bulgaria, in Czechoslovakia and in Jugoslavia.

In Poland the lower arms only are duplicated.

In the United States a board is fixed to the signal on which is indicated the number of tracks.

I suppose that the signals, shewn in figure 5, can be employed in this case as recommended by the U. I. C., for their use is highly justifiable.

Question 8. — No system notifies changes in the form of the signals in case of periodical supervision.

D. — General information.

Question 1. — The majority of the railways use white and red for painting barriers and signals.

Question 2. — From the replies received concerning the illumination of the barriers at crossings, it appears that the majority of the systems find it necessary to illuminate crossings having intense traffic.

Question 3. — In connection with the preceding point and having regard to the good results which the special devices for reflecting the light from the head lamps of automobiles give when placed on the signals at crossings in the U. S. A., they might be recommended for barriers normally closed and operated at a distance as well as for barriers which are not well illuminated.

The replies from the systems exhibit great diversity and give the impression that only a few experiments have been made in this direction.

Czechoslovakia has obtained good results by using glasses which reflect the light from the head lights of automobiles.

Proposed uniform regulations for the protection of railway crossings, signal types and visibility conditions.

On the basis of the preceding résumé the following principles may be extracted bearing on the protection of crossings as well as on the types of signals and the conditions of visibility .

1. *Arrangements for the protection of crossings.*

At crossings on lines where the speed does not exceed 15 km. (9.3 miles), if there is automobile traffic on the road, a triangular sign, in accordance with the Convention of 1926, is considered to be sufficient.

In the cases where the crossings on the lines in question would not have a sufficient visibility, it would be necessary to instal, at a distance of L = 5 V = 75 m. (247 feet) alongside the track, signals instructing the driver to whistle and, if there is automobile traffic, a similar supplementary signal at a distance of L = 3 V = 45 m. (147 ft. 8 in.).

At crossings of good visibility and in cases where the speed of trains is greater, it would be necessary to erect, on both sides of the line, fixed St. Andrew's cross signals (figs. 4 and 5); in case there is automobile traffic, triangular signals, in accordance with the 1926 Convention, would be erected.

In cases of insufficient visibility, it is necessary, instead of the fixed St. Andrew's cross signal, to erect an automatic optical signal surmounted by a similar cross (fig. 8) with the addition of bells if there is an exceptionally heavy traffic of pedestrians.

These two systems of protecting level crossings are sufficient when the product of the number of vehicles and the number of trains in 24 hours is not over 70 000, if, however, the number of trains is not greater than 100.

If the traffic on the road is more intense than that in question above (> 70 000), barriers must be utilised, painted in white and red and well lighted, and exceptionally, provided with reflecting lenses if a sufficient illumination is difficult to obtain.

These barriers ought to be closed two minutes before the arrival of the train. An installation of automatic bells is recommended to warn the gatekeepers of the approach of the train.

The distance between the barrier and the centre of the adjacent track may be fixed at 3 m. (9 ft. 10 in.) as a general rule, and at 8 m. (26 ft. 3 in.) for barriers operated at a distance of :

I. Less than 50 m. (164 feet) if they are not clearly visible from the control post;

II. More than 50 m. (164 feet) if they are not clearly visible from the post and if the ringing of the bells is not of sufficient duration to enable the crossing to be traversed.

As an exception, it is permissible to replace automatic signalling, even in the event of absence of visibility, by fixed signals, when the speed of the trains is not greater than 50 km. (31 miles) per hour and the number of vehicles does not exceed 150 in 24 hours, with few motor buses among the vehicles; in this case it would be necessary to order compulsory stopping of the vehicles and to instal signals at a distance of L = 3 V and L = 5 V instructing the driver to whistle.

Barriers would have to be replaced by over or under bridges if the product of the number of trains and the number of vehicles in 24 hours is greater than 800 000, or if the number of trains exceeds 400 in 24 hours. Exception would be made for lines having trains of the tram type.

At crossings requiring partial supervision during the day, it is necessary nevertheless to provide fixed signals, or if the visibility conditions demand it, automatic signalling and no barriers. The barriers, raised at periods of non-supervision are misleading to users of the road.

There will be found below the scheme of signal types as well as that of the visibility standards.

2. *Scheme of signal types and instructions for their installation.*

To be adopted, uniformly, the St. Andrew's cross shape, as shewn in figure 4, the lower arms to be duplicated at cross-

ings having several tracks, in accordance with figure 5. The signal should be placed at a distance of 5 m. (16 ft. 5 in.) from the outside rail, at the side of the road on both sides of the railway. The post should be painted grey, the arms of the cross alternately white and red. On the post of this signal there should be affixed a board, size 30 × 60 cm. (11 3/4 × 23 1/2 inches) with the inscription, say, « 25 km. » (« 15 miles ») in white letters on a black ground. It would be recommended that to these letters should be fitted lenses for reflecting the light from automobile head lamps.

At crossings where the stopping of vehicles is compulsory, these boards would have dimensions of 55 cm. by 60 cm. (21 3/4 in. × 23 1/2 in.) with the inscription « Stop ! » in the language of the country, and above the inscription « 0 km. » (0 mile) for international traffic.

Preference must be given to automatic flash light signals, with the lights placed horizontally on both sides of the post, at a distance of 76 cm. (2 ft. 5 7/8 in.) between the lenses and at 2.40 m. (7 ft. 10 1/2 in.) at least, above the level of the road, as shewn in figure 8.

At crossings with less intense road traffic, signals may have only one light, set on a post at the side of the road, at a distance of 38 cm. (15 inches) from the centre of the post.

The white light of automatic signals ought to flash continuously at the rate of 40 times per minute; during 30 seconds, as a minimum, before the arrival of the train a red light must flash at the rate of 80 times per minute.

The flashing of the red light ought to continue until the last wagon of the train has left the crossing. For the lighting of the signals electricity is used, or in default of this, acetylene.

The optical signal ought to be surmounted by a St. Andrew's cross whose arms ought not to stretch beyond the limits of the flash lights.

A supplementary bell signal is not compulsory. On the post of the automatic signal would be placed boards carrying the inscription, say, « 25 km. », similar to the model specified for fixed signals and, also, a warning to stop in case of absence of the white light.

The nearest approach to the above description is the type of signal adopted by the American Railway Engineering Association. This type, modified according to the principles mentioned, is sketched in figure 8.

The fixed or automatic signal, on roads having automobile traffic, ought to be preceded by a sign, in accordance with the 1926 Convention, painted in white and red, placed at a distance of at least 60 m. (197 feet), [in towns not more than 30 m. (98 1/2 feet)], but not exceeding 135 m. (443 feet), as is practised in the U. S. A.

In the case where this signal would be fixed at a greater distance from the crossing (up to 250 m. = 820 feet) it would be necessary to place, between the said signal and the crossing, distance-indicating posts as illustrated in figure 9.

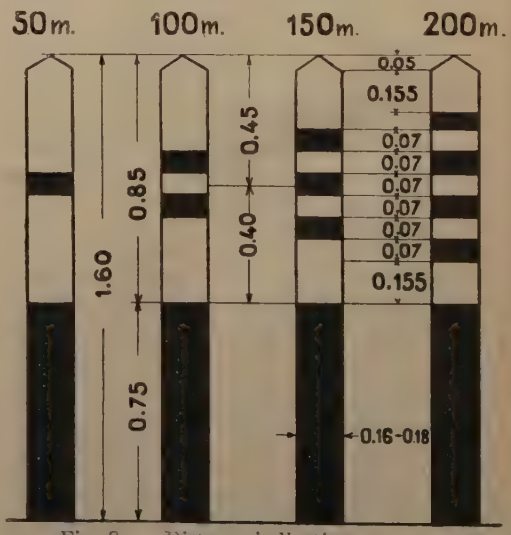

Fig. 9. — Distance-indicating posts.

3. *Scheme of regulations concerning visibility at level crossings.*

To be agreed that the conditions of visibility are sufficient, if the driver of the vehicle, which is moving along the road at a moderate speed, perceives the train at a distance $a\ k = 8$ m. (26 ft. 3 in.), on the section $k\ d = L = 5\ V$, where V is the maximum speed which the train can attain at the given place and in the given direction; as a rule it is the maximum speed allowed on the line in question (fig. 7).

If the road is intended for and occupied by automobile traffic, the driver of a fast moving vehicle ought to perceive the train at a distance $b\ k = 20$ m. (65 ft. 8 in.), on the section $k\ c = L = 3\ V$.

As for crossings with more than one track the above mentioned visibility distances must be increased, as follows :

$$k\ d = L = (5 + 0.25\ d)\ V;$$
$$k\ c = L = (3 + 0.075\ d)\ V;$$

a and b are at 1.30 m. (4 ft. 3 in.) above the road level;

d and e are at 1.50 m. (4 ft. 11 in.) above the rail level.

FINAL SUMMARY.

Experience acquired since the London Congress proves that the decisions taken there to restrict the supervision of level crossings are justified. The practice of recent years gives us the possibility of determining rules for protection in a more detailed manner.

Since, thanks to the use of automobiles, local road traffic, not only becomes transformed into high-speed traffic on a wide scale, but becomes more and more international traffic, it is necessary to create legislation and uniform regulations in all the countries, concerning protection of level crossings, in the same way as it is a matter of urgency to decide upon standard types of automatic signals, fixed warning signals and other installations at crossings.

Whilst, in the age of slow moving road traffic, the level crossing was the most dangerous part of the road, statistics relating to the growing motor traffic demonstrate to us that accidents, at crossings, constitute in fact only a small percentage of all the accidents on roads.

In principle, the abolition of level crossings by the construction of over- or under bridges cannot be taken into consideration as a more or less general rule, on account of the exhorbitant expenditure which it necessitates.

As the increase of the difficulties at crossings has been provoked by the activity, hitherto unknown, of the road traffic, it is the road which ought to assume the costs of the construction of over- or under bridges as well as those for the increased protection of the crossings, necessitated by the development of road transport.

From the point of view of general economy and taking into account the considerable costs, an endeavour should be made to reduce, so far as possible, the number of crossings of roads and railways, by abolishing little frequented crossings, and diverting the traffic to those which, having a more accentuated road traffic, are equipped with an adequate signalling system and by constructing over- or under bridges at places where the maximum concentration of road traffic is to be found. In elaborating schemes for the construction or reconstruction of roads these facts must be given due weight.

It must be recognised that at crossings where visibility is good, fixed signals can in general, suffice, and that if the visibility is defective, the best means of protecting the crossing would be the automatic signalling of the approach of the train by the use of flash lights.

Remembering that the majority of accidents at supervised level crossings are due to the collision of vehicles with the barriers (the keepers are even knocked down at times by motor cars) it would be ne-

cessary to endeavour, whilst taking financial possibilities into account, to replace the barriers by fixed or automatic signals, according to the growth of mechanically propelled transport and to retain barriers only at crossings with very intense automobile traffic, when automatic signalling is insufficient and direct supervision of the barriers and regulation of road traffic seem necessary.

It must be admitted that fixed signals can equally well be placed at crossings of insufficient visibility even if the railway traffic is limited as to speed and the road traffic is not heavy.

It must be recognised that the obtaining and maintaining of conditions of visibility regulated by the standard requirements for level crossings in all countries are of very great importance; it would then be necessary to publish corresponding regulations.

At unsupervised crossings, clearly visible or possessing an automatic signalling equipment, the speed of road traffic ought to be limited. At crossings of insufficient visibility or without automatic signalling, the stopping of vehicles ought to be compulsory.

In both cases, these arrangement ought to be brought to the notice of the public by appropriate notices on the signals.

[385.524 & 385.587]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION X :

Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

REPORT No. 1

(Belgium, Spain, France and their Colonies; Great Britain, Dominions and Colonies; Luxemburg; Netherlands, Portugal and their Colonies),

by E. SOULEZ,

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Introduction.

The title of Question XV set at the International Railway Congress of 1930 was :

« Co-operation of the staff towards increased efficiency and its participation in the profits. »

During the discussion of this question at Madrid, it appeared that the members of the Congress desired that the debate in which they took part should be widened and that, for the next Congress, Question XV of 1930 should be changed into a question having a wider definition.

The Permanent Commission of the Congress has satisfied this wish and, while maintaining on the programme for 1933 the question as previously set, has given it a singularly wider scope by wording it as follows :

« Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits. »

By the « Scientific organisation of work in a railway department » is understood the whole of the measures which are intended to speed up operations and to reduce their cost, in other words : to increase the efficiency of the undertaking constituted by a railway.

Among the measures which answer this purpose, we have, on the one hand, the group of measures which are expressed in the form of functional changes in the departments of a railway or of a group of systems, and also in the form of improvements in plant and tools.

The methods to be found in this group

are numerous and vary from those which relate to rationalisation, which affect the whole of the railway industry and the railways in their essential organisations, to those which are branches of rational organisation and which apply to different elements of one and the same railway, while each of these elements may give rise to extremely detailed studies of organisation. All these measures raise problems of an administrative, technical and financial character.

On the other hand, there is the group of measures which apply not to the entity of the « Railway System » but to the human being, the man, the railway employee, whose daily effort enables the organisation of which he forms part to live and prosper. The measures affect everything which concerns the professional man, the *homo faber :* health, safety, remuneration, training, discipline, confidence, collaboration, loyalty, emulation, sports, etc. These elements correspond to needs of the human being which scientific organisation is far from ignoring, but which it employs and develops, thus increasing the value of the individual, while at the same time strengthening the solidity of the common undertaking.

The methods which deal with the man, the railway employee, are of a social, physiological, psychological (or to use a modern expression psycho-technical) order.

The measures which railways have been able to take in order to improve the efficiency are not always of one order : solely administrative and technical or social and psychological. In most cases, they comprise elements of several different orders. It is evident, for instance, that one method cannot be replaced by another leading to a better efficiency without bringing into action certain moral forces of the employees which permit them to take an interest in the changes and to co-operate with a good will in the endeavour for improvement.

In the following report, therefore, a place ought to have been allotted in each of the chapters to administrative and technical questions as well as to social and psychological questions. It appeared to the reporters that such a plan would have led to results difficult to analyse and they therefore decided to divide their report into two clearly distinct parts.

It will still be understood, of course, that in the opinion of the reporters, such a division does not correspond to the reality of daily life and has merely been made for the clearness of the report which they are submitting.

The reader will perhaps be surprised to find in the following report, very detailed accounts of the arrangements made by some railways, while those employed on other railways which also are certainly interesting, have received very brief mention. This apparent anomaly is due to the fact that the reporters have had to base their statements on the replies to the preliminary questionnaire which was sent to all the Administrations. These replies were more or less detailed according to the Administrations answering, whence the inevitable inequalities in the length of the corresponding accounts.

Often, also, the same ideas have been explained by different organisations, and have therefore been merely enumerated.

Finally, some reports were received by us too late because, by the 15 January, on which date the present report was drawn up, only 32 Railway Administrations had given positive replies out of a total of 121 Administrations who were consulted.

FIRST PART.

Financial, administrative and technical questions.

General.

The questions to which the different railways have turned their attention and

which they have examined from the point of view of the organisation of work, differ widely. One railway, for instance, has made a special study of the rational operation of marshalling yards, another the mechanisation of the work of track relaying another the organisation of the main repair shops, and yet another, the simplification of book-keeping, etc. The result is that, although all these problems have given rise to extremely interesting studies, their solutions are scattered over the Administrations as a whole.

On the other hand, under the expression « Scientific Organisation » we generally distinguish :

Rationalisation, which affects the management of the whole of a railway.

Rational organisation of the different sub-divisions.

Standardisation of the elements utilised.

The reporters therefore considered it necessary to divide the first part of their report into three chapters corresponding to the three orders of ideas indicated in the foregoing.

The order in which they have classified these chapters : rationalisation, rational organisation, standardisation, does not anticipate the order in which it has been possible to revise the old methods. The re-organisation of an undertaking may, from the start, influence all the manifestations of its activity.

Moreover, in order to conform to the indication provided by the wording itself of question X (Instances of the application... of scientific organisation...), they have refrained from referring systematically to all the solutions which have been mentioned by the railways, but have, on the contrary, endeavoured to extract from their information the most typical cases in which the principles of scientific organisation have been applied.

CHAPTER I.

Improvements realised in the general organisation of a railway or group of railways (Rationalisation).

General organisation of a group of railways, concentration, grouping.

Generally speaking, a large railway as it appears at the present time, is the result of the grouping of several railways. In fact, in the beginning of railways, the various Companies who exploited the new form of locomotion were content to connect one town to another. Subsequently, they were grouped together to form homogeneous railways. Moreover, in being grouped together, the different constituent railways experienced an increase in the financial power of the combined undertaking, which enabled temporary losses to be borne without endangering the undertaking, but above all which provided the new undertaking thus formed with the necessary means for expanding its field of operations, particularly by the construction of new lines. Finally, the grouping of several such undertakings into a single undertaking was of necessity due to the institution of a single control, followed by considerable reductions in the general expenses and appreciable improvements of a technical order.

Such grouping finally afforded certain advantages for the user who had henceforth only to deal with a limited number of transport organisations.

It is difficult to decide the extent up to which grouping of railways is useful or even simply desirable, when we take into consideration the inherent disadvantages of very large undertakings. It would appear, however, that it is evidently of interest for a railway to serve the whole of regions possessing a con-

siderable geographical or economical homogeneity. It is this law, to some extent a natural law, which has controlled more or less directly the various railway groupings mentioned.

In face of the impossibility of summarising all the replies which we have received on this subject, we shall confine ourselves to explaining by way of example the manner in which the *Paris-Orleans Railway Company* was formed.

This Company was originally established on the 11 August 1838 for the operation of the line from Paris to Orleans via Etampes with branches leading to Corbeil, Pithiviers and Arpajon. The line, which extended over 121 km. (75 miles) was opened in 1843.

As the first instance, we note the amalgamation in 1852 of the concessionary companies of the lines from *Paris to Orleans*, of the *Centre*, from *Orleans to Bordeaux*, from *Tours to Nantes;* the new undertaking retained the name of the oldest of the amalgamating undertakings, that is to say, *Paris-Orleans Railway Company.*

In 1855, we note the absorption of the *Paris-Orsay Railway,* itself constituted by the *Paris-Sceaux* Company and the *Bourg-la-Reine-Orsay* Company.

As a result of the splitting up of the *Grand Central* Railway which, constituted in 1853, was not destined to prosper on account of its peculiar situation in between the three Companies the *Paris-Orleans*, the *Paris-Lyons* and the *Midi*, an agreement made in 1857 between these Companies granted to the Paris-Orleans Railway a portion of the lines of the unsuccessful undertaking. In return, the Paris-Orleans Company ceded to the *Paris-Lyons* Company and the *Lyons-Mediterranean* Company its part in the concession of the *Bourbonnais* lines.

In 1853, this Company ceded the lines from *Nantes to La Roche-sur-Yon*, from *St. Benoît to La Rochelle and Rochefort*, from *Château-du-Loir to St-Calais* to the *State* Railways which were thus clearly bounded by the triangle formed by the lines from *Tours to Nantes, Tours to Bordeaux* and the Ocean. In exchange, the *State* Railways handed over to the *Paris-Orleans* Company ten lines scattered over the territory of the latter company, viz., the main line connecting *Clermont to Angoulême* which, with its branch lines, divided the *Paris-Orleans* Railway transversely.

Finally, the *Paris-Orleans* Railway Company has developed its railway by obtaining the concession of new lines which it put into operation.

The present railway has been formed by these successive modifications.

Like the *Paris-Orleans,* the other French railways are the result of the grouping of several railways.

The railways of Great Britain have felt much less strongly than the Continental railways the need for combining, on account of the insularity of Great Britain which isolated these railways from the principal continental lines of communication. Thus, in 1920, the number of Companies operating the railways of this country was 120. These different companies amalgamated in 1921 to form four groups only. The causes for this amalgamation principally reside in the economies which can be realised thereby and in a more rational organisation of railway transport operation in Great Britain.

Other examples of grouping have been mentioned to us by the *Netherlands* Railways, *Portuguese* Railways, *Andalusian* Railways and the *North of Spain* Railway.

Of the non-European railways, the *Canadian National* Railways, the *South African* Railways, the *Eastern Bengal* Railway, the *Malay States Railways*, the *Thiès to the Niger* Railway and the *Algerian* system of the *Paris-Lyons-Mediterranean* Railways are likewise the result of groupings of railways.

General organisation of the railway systems.

A railway, like all other undertakings, comprises a general headquarters office and executive offices conveniently distributed among the various working centres. By the very nature of the functions of a railway, these various offices are distributed over often fairly extensive geographical regions. For this reason, it has generally been deemed indispensable to create regional subdivisions by way of relays between the general headquarters office and the executive offices. Moreover, bearing in mind the different duties carried out by the employees, it has been found necessary to set up extensive technical departments at the general headquarters office, with a view to unifying the methods of operation.

The different organisations : management departments, technical departments, divisional departments, local departments, constituting a railway, may be grouped in regard to their organisation in different ways, and the railways have endeavoured to find the most profitable to adopt in the various special cases. The general schemes of organisation which have been sent us may be classified in three well defined types :

The first type is afforded by the *London & North Eastern* Ry., the *Canadian National* Rys. and the *South African* Rys. It is based on a geographical division of the lines operated in a certain number of regional managements, having authority over the whole of the staff depending therefrom, irrespective of the speciality of the said staff. The general manager's office comprises the departments common to the whole of the railway, that is to say, not merely the purely administrative and financial departments but also certain technical or commercial departments.

Figure 1 shows the scheme of organisation of the *London & North Eastern* Railway.

On the *Canadian National* Rys., the regional managers are directly responsible to a vice-president who likewise comprises under his authority the central technical departments, permanent way, rolling stock and locomotive running, operating, luxury trains service.

The second type, which is generally employed on the French railways and French colonial railways is characterised by the division into three departments :

Operating department,

Rolling stock and locomotive running department,

Permanent way and works department.

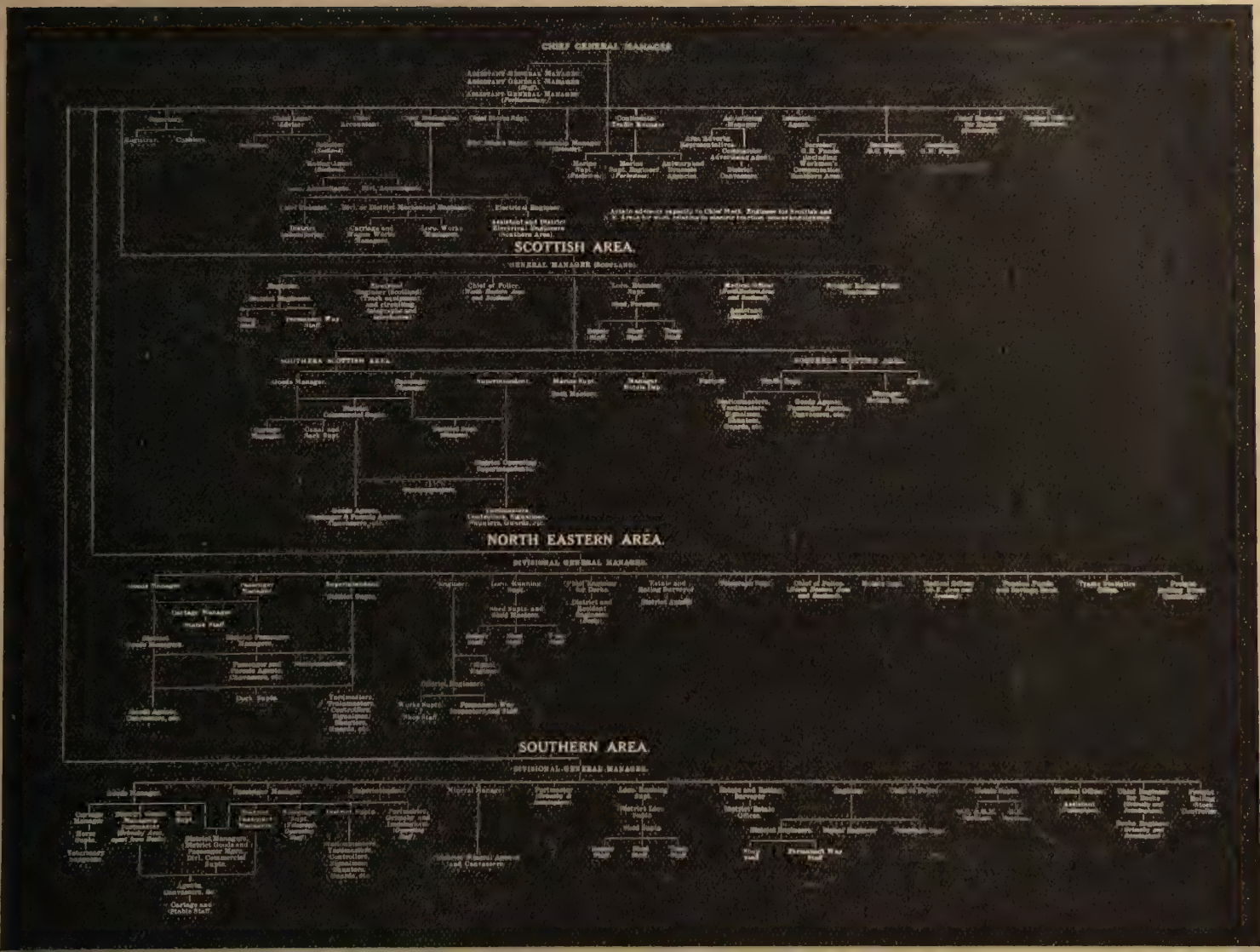
These departments have their own staff and extend parallel to each other on the lines of the railway. The actual managing organisation only comprises purely administrative and financial departments. See figure 2 showing the scheme of the organisation of the *French State* Rys.

The *Sudan Government* and *Franco-Ethiopian* Rys. are organised in accordance with this type.

The organisation of the *North of Spain* Railway corresponds to this type with the modification that the number of departments is four instead of three, owing to the division of the operating department into a technical operating department and a commercial department.

The scheme of organisation of the *Great Western* Ry. (England) belongs to this type, although from the commencement a more extensive division of the working departments (traffic, locomotive department, traction, permanent way, signals, stores, docks, etc.). A similar remark applies to the *Netherlands* Rys.

From a certain point of view, the organisation of the *London, Midland & Scottish* Ry. may be included in the French Railway type of organisation, due to the fact that there are no regional managers. However, the distribution among the general departments of the


CHIEF GENERAL MANAGER
SCOTTISH AREA.
GENERAL MANAGER (SCOTLAND).
NORTH EASTERN AREA.
DIVISIONAL GENERAL MANAGER.
SOUTHERN AREA.
DIVISIONAL GENERAL MANAGER.

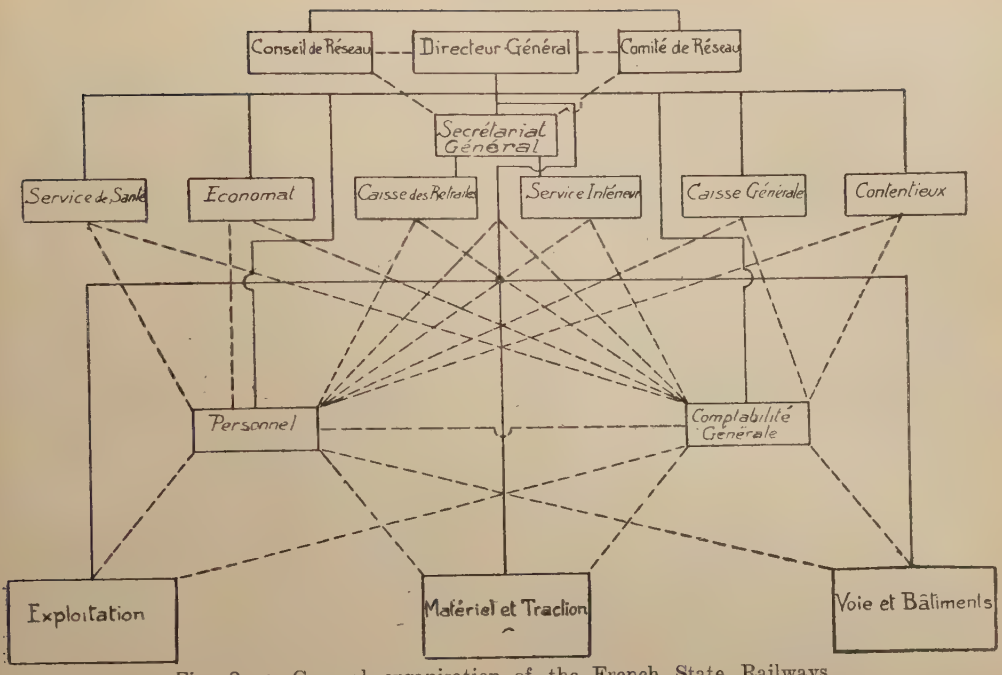


Fig. 2. — General organisation of the French State Railways.

Explanation of French terms:

Conseil de réseau = Railway Council. — Directeur général = General manager. — Comité de réseau = Railway Committee. — Secrétariat général = General secretariat. — Service de santé = Health service. — Economat = Supply stores. — Caisse des retraites = Pension fund. — Service intérieur = Internal service. — Caisse générale = General cashier. — Contentieux = Legal. — Personnel = Staff. — Comptabilité générale = General accountancy. — Exploitation = Operation. — Matériel et traction = Rolling stock and locomotive running. — Voie et bâtiments = Permanent way and buildings.

various organisations constituting the railway differ essentially from that which has been indicated as characterising the second type of scheme of organisation. Actually, these different organisations are combined into four groups each placed under the control of a vice-president.

One group comprises the common departments : Accounts, legal department, staff, etc. It forms what has been called the management proper. The second and third groups comprise the operating and commercial departments. The first of these groups deals with the passenger service and the second with the goods service. On the other hand, these two groups possess a joint maritime and continental operation organisation. Finally the fourth group comprises the permanent way and buildings department and the workshops department.

Under these conditions, the rolling stock and locomotive running department, as it exists in the organisation of the second type, does not exist on the *London Midland & Scottish* Ry., the departments which would constitute this department being distributed as follows : the rolling stock departments (passenger and goods) are attached respectively to the second and third groups (passenger operating and goods operating). The actual locomotive running department is attached to the second group (passenger operating). Finally, the rolling stock and locomotive repair shops are attached to the fourth group.

The third type of general organisation

is provided by the *Belgian National* Railway Company.

The organisation of this railway exhibits the peculiarity of being a mixture of the organisation of the *London & North Eastern* Ry. and that of the *French* railways. Actually, like the French railways, it comprises one central administration divided into a number of large technical departments, including the operating department, rolling stock and locomotive running department and the permanent way department, but, as on the *London & North Eastern* Ry., it also involves a geographical division of the lines into a certain number of regional groups.

Connections between the various departments of a railway.

Between the different departments which constitute a railway, there are direct connections between the heads of departments or indirect connections, i. e. via the superior grade, for example, the management.

Independently of these normal connections, most railways make use of conferences as a means of rapidly solving problems. These conferences bring together once or several times a week the heads of departments or the qualified representatives of the various departments down to and including certain local officials.

The *Paris-Lyons-Mediterranean* Rys. state that the connection and collaboration between the three main active departments are ensured by an operating manager attached to the general manager. The *Sudan Government* Railways intend to improve the connection between the locomotive running and the traffic departments by making these departments coincide as far as possible.

Connections between several railways.

Railway traffic being essentially long-distance traffic, of a length even going beyond the frontiers of countries, the railways of different countries have felt the necessity of coming to some agreement to deal with questions of a common interest, particularly the administrative and technical conditions of the exchange of rolling stock. It is in this spirit that the different international associations grouping the interested Administrations have been established.

When several railway systems exist together in the same country, these relations become closer. They may go beyond the technical or administrative sphere and touch on financial questions.

We may mention the case of the *French* railways, the efforts of which are co-ordinated by organisations such as the superior railway council, the management committee of the large railways, the meetings of the managers and the heads of the principal departments.

General organisation of the operating, rolling stock and locomotive running, permanent way and buildings departments.

The constitution of these departments in the different railways does not exhibit sufficiently particular features to require special consideration.

The problems of inter-connection alone have often found interesting solutions.

Thus, in all departments, regular conferences have been instituted for bringing together the officials of the central and regional departments to enable numerous questions to be settled by verbal discussion and to maintain the spirit of fellowship in the managing staff of all grades.

Organisations common to several departments.

Apart from the general departments, which are to be found on all railways (general office — general accounts — legal) and which in reality are not organ-

isations common to several departments but form part of the whole of the departments constituting the general management, some railways mention organisations, the duty of which is to ensure a more perfect connection and a closer collaboration between their departments, and more particularly between those directly interested in traffic questions (operating department — locomotive running department).

Among the various organisations which have been mentioned to us, we will first of all cite the following :

The controlling centres (dispatching system) employed by almost all the *British* and *French* Railways, and the *Belgian National* Railway Company, and which are common to the operating department and to the locomotive running department.

Everyone knows that the principle of the « Control » consists in concentrating all the information relating to the running of the trains of a section in the hands of one employee called the controller, so as to ensure regularity of running and a better utilisation of the lines, locomotives, rolling stock and travelling staff.

In this connection, there are two formulæ in existence :

In the first, the authority and initiative of the local employees (stations and signal boxes) have been partly maintained, in which case it is the duty of the controller to supervise and to direct the trains on the lines or group of lines within the sphere of his activities. He only interferes in very well defined cases with the internal working of stations, the latter continuing to direct operations.

In the second form, the controller regulates and orders the movement on the section entrusted to him. He it is who authorises the running of optional and special trains. Moreover, if he considers it necessary, he completely changes the route inscribed on the table for any train so as to allot to that train another regular, optional or special route suitable to the state of the traffic.

A graph on which is shown the exact position of the trains with the aid of information received directly from the stations and signal boxes of the sections enables the controller to carry out his duties in the best possible manner and to take the necessary steps with the least delay.

According to the magnitude of the traffic to be controlled, the locomotive running and operating duties are covered by two distinct employees which work in common, or by one employee. In this case, owing to questions of the movement of trains and the safety of operation preponderating, an operating employee fulfils the duties.

The duties of the control employees may not be limited to controlling the running of trains but may likewise include the supervision of the locomotive running and operating employees ensuring the service of these trains.

Reference may likewise be made to the following joint organisations existing on certain French railways, and more particularly on the State Railways and the *Nord* Railway :

1. The work organising committee, common to the three main departments (operating — rolling stock and locomotive running — permanent way), directed by a chief engineer attached to headquarters and assisted in his duties by a sub-committee likewise composed of employees of the three departments.

The functions of this committee are to study the problems of the organisation of the work and, after their proposals have been approved by the manager, to collaborate in the perfection of these proposals and in their employment by the departments.

2. The special loads committee composed of an official from each of the departments : operating — rolling stock — permanent way, whose functions con-

sist in settling all questions relating to the transport of heavy or bulky objects (examination of the method of loading — choice of the rolling stock — verifying the loading gauge, etc.).

3. The tripartite safety and regularity committee comprising an employee from each of the three departments : operating, locomotive running and permanent way. The functions of this committee are to supervise the carrying out of the service on the whole of the railway from the point of view of the effective and correct construction of safety devices and their understanding by the employees, and from the point of view of the precise causes which are at the root of irregularities in the running of the trains.

This committee puts forward every measure capable of making the desired improvements and sends in an account of its work every week to the general manager.

4. The accidents committee which meets once a week under the chairmanship of a chief engineer attached to the management and which is composed of a superior grade employee from each of the three main departments.

The functions of this committee are to examine incidents which have, or might have, resulted in accidents, and to obtain therefrom information for avoiding their repetition.

The *State* Railways also mention :

— staff conferences, electrification committee meetings attended by employees from each of the three main departments (there is also an electrification committee conference on the P. O.).

— The committee of two for permanently made up trains, comprising an employee from the operating department and an employee from the rolling stock department entrusted with the formation and maintenance of trains of permanently formed rakes.

— The level-crossings committee of two, composed of employees, one from the permanent way department and the other from the operating department, whose functions consist in examining the possible modificatons in the level crossings statute, each considered separately (possibilities of guarding the crossings by the neighbouring station — abolition of guarding, etc.).

Finally, reference should also be made here to the fact that the railways of the *British Empire* consider the stores department as a common organisation. The *Paris-Lyons-Mediterranean (French and Algerian* lines), who possess a similar department mention that the grouping of purchases permits them to obtain more advantageous prices from the manufacturers.

CHAPTER II.

Improvements in the methods of working, installations and tools (Rational organisation of the work).

Headquarters. — Administrative work.

Headquarters.

Headquarters comprise a certain number of offices attached to the different departments or departmental subdivisions. These offices group the employees who are under the orders of the heads of department, engineers and inspectors to supplement them in all duties not expressly necessitating their intervention. The result of this organisation is that each office is more or less specialised in a part of the department.

Independently of these offices, which are specialised by the nature of the matters dealt with, there are generally to be found at headquarters, offices which concentrate a certain function for the whole of the departments for example a central correspondence office entrusted with the reception, booking and despatch of the mail, a central typing office, a central registry, etc. The present ten-

dency appears to be to form a large number of offices of this type by centralisation.

From the point of view of their management, these offices are under the control of a chief clerk in charge assisted by assistant chief clerks and clerks in charge of groups.

Improvements in the administrative work.

The administrative work is composed partly of manual work and partly of intellectual work which are frequently confused with each other.

It is *a priori* always possible, by employing suitable devices, to facilitate the manual work involved in a given piece of administrative work. The question is reduced to one of determining the period of depreciation of the capital involved.

The problem becomes more complex when we come to the case of intellectual work. Although mechanisation, when judiciously applied, enables the time spent on some of this work to be reduced by substituting mechanical work for brain work (for instance, in the calculation of accounts, statistics, in transferring information from one document to another), it is on the other hand impossible to employ these methods alone in order to improve other work of an intellectual character, such as making decisions, drawing up and indexing documents, etc. However, work of this kind may be considerably facilitated by a satisfactory general organisation comprising more particularly highly developed means of co-operation and indexing.

The following are the various measures mentioned by the railways :

— Re-grouping of offices.
— Equipment of offices.
— Use of the automatic telephone.
— Institution of periodical conferences between departments with the object of speeding up the settlement of joint affairs.
— Investigation of the capability of employees with a view to employing them to the best advantage.
— Revision of instructions and orders in force so as to make them clearer and to adapt them to new conditions.
— Revision of forms in use.
— Reorganisation of the registry.

In order to avoid overlapping, some Railways have created a single registry per department. On this occasion, the indexing of files has been revised. The methods employed are generally based on the decimal system. The use of a letter instead of a number in denoting a file allows twenty-six indexing branches instead of ten to be differentiated under one sign.

In regard to the equipment of the filing office, vertical or upright filing is generally preferred, since it provides a saving in space and consequently means less fatigue for the employees using the room.

The filing office or registry should not be regarded as being merely a store for files, but as an organisation which takes part in the life of the office itself and is in direct communication with those in charge of the circulation of documents. It is essential, therefore, that, on its arrival in the office, each document should be taken in charge by the filing department.

The *Est* in this connection, mentions the following mechanism :

« In the general rolling stock and locomotive running department, documents on arrival are marked with the date of reception and numbered by means of a dating and numbering stamp. The same number is stamped on the original document and on all papers appended to it.

The document is then entered on an « Entry sheet » which is typed in three copies :

Copy No. 1 is placed in a binder constituting an index of the entries. Copy No. 2 is placed in a tickler at the date on which the matter is to be brought to

the attention of the department concerned, if the necessary action has not been taken by that date. If action has been taken, this is mentioned on the index sheet (copy No. 1). The third copy is placed in the file of the matter during the absence of the original sheet. The number of this file is entered on the index sheet (copy No. 1).

— Use of card indexes.

The cards employed are either vertical or horizontal. Vertical card indexes are suitable for sorting a large number of cards in a given space. However, they are not so clear as horizontal card indexes. Horizontal card indexes which are more expensive than the vertical indexes are essential whenever documents have to be handled considerably. When the card index cabinets become excessively large, the « Roule Class » (rolling) type is employed.

The following are examples of some interesting uses of card indexes taken from those mentioned by the Railways :

Inventory of pensions paid to retired employees.
Payment of quarterly arrears of employees.
Tarpaulin accounts.
Registering documents.
Matters to be followed up.
Contractors' accounts.
Movements of wagons.

There are special types of cards corresponding to well defined uses, for example cards selected by perforations, the use of which is mentioned by the *Est* Ry. for classifying applicants for posts.

— Use of modern methods of copying documents.

The anxiety to make the best use of short-hand typists has induced some Administrations to collect this staff in a central office (*French State* Rys., the *Est* and the *Paris-Orleans*).

Other measures have also been taken to reduce the fatigue and to increase the comfort of typists. We may mention the provision of chairs of adjustable height and depth capable of turning in all directions, swivelling lamps, special copy holders in which the line to be copied is always indicated by a movable pointer operated by means of a key similar to those of the machine and placed in line with them.

In addition, efforts have been made to reduce to a minimum the time passed in the subsidiary operations of the typist by the use of special machines in which the carbon paper is inserted automatically between the sheets or by using with ordinary machines forms, the back of which is coated with a copying substance.

— Use of calculating machines (1).

Calculating machines comprise printing-adding machines, true calculating machines and finally so-called book-keeping machines.

The Railways mention a fairly extensive use of these three types of machines. The necessity of utilising them to the fullest extent has frequently meant the concentration of certain book-keeping work in one office. For instance, the calculation of wages which, in some Administrations, was done by the different works is now frequently combined in the central departments. The *Paris-Orleans* Ry. mentions the existence of a single office for the preparation of the wages of the whole of its 65 000 employees. This system has enabled the effective numbers of the employees to be reduced by 95. The *Belgian National* Railway Company has also entrusted the making up of the salary sheets of the officials

(1) See Reports of the XIth Session (Madrid, 1930). Question XIV : The use on the railways of mechanical means for simplifying statistical and accountancy work.

and employees of the entire railway to one organisation, the wages of the workmen employed by the executive departments being drawn up by each man's immediate superior.

— Use of statistical machines (1).

These machines comprise perforating machines, sorting machines and tabulating machines.

Most Railways mention a fairly frequent use of these machines (2). It is remarked that the basic document must be adapted to the use of these machines.

The principal uses of statistical machines are :

Magnitude of the traffic. — Mileage and rate. — Tonnage on departure. — Receipts per mile. — Tonnage per mile. — Gross tonnage hauled by locomotives. — Distance run by locomotives. — Time gained and lost by drivers and firemen. — Premiums of these employees. — Various expenses : permanent way maintenance, repair of locomotives and vehicles per mile operated, price of transport per mile or per ton-mile, fuel consumption per mile, etc.

— Mechanical devices for the transport of files, documents, etc.

Apart from the lifts, the use of which appears to be general in the Administrations for facilitating the duties of messengers, there are more up-to-date devices for transporting documents or files directly from one point of use to another, these points being situated in one office or in offices at some distance apart according to the case. Instances of the use of these devices, which are based on the employment of belts, trolleys or pneumatic tubes, are still rather rare. The *Nord* Railway mentions the use of a pneumatic tube for transmitting telegrams and another tube of larger dimensions for transmitting files between the record room and the correspondence office of the operating department.

— Miscellaneous machines.

These machines comprise addressing machines, franking machines, invoicing machines, etc., of very special use mentioned more or less frequently by the Railways.

In this connection, special reference should be made to ticket printing machines, the use of which is rapidly extending.

Operating department.

Organisation of the technical offices.

The technical offices of an operating department examine schemes for the extension and installation of stations, signalling plant, interlocking plant, etc., which are frequently worked out in co-operation with the permanent way department whose duty it is, in almost all cases, to bring the proposals into concrete form and to superintend the execution of the work.

In regard to the organisation of these offices, the Railways have investigated as first condition the specialisation of each of the offices or their subdivisions in the study of well defined questions. Thus, on the *Paris-Orleans* (P. O.) Railway, there are four technical sections of which :

— one is responsible for schemes for the extension and improvement of fixed installations (permanent way; buildings; lighting; shunting and goods handling appliances);

— another, the signals and interlocking devices;

— a third, private sidings;

— and the last, the leasing of land to third parties.

(1) See Report of the XIth Session (Madrid, 1930). Question XIV : The use on the railways of mechanical means for simplifying statistical and acountancy work.

(2) Mechanisation of office work. Lectures by Mr. Boll. « Confédération générale de la production française », 24 October 1930, and « Comité national de l'organisation française », 19 March 1931.

Finally, an additional general office is in charge of the keeping and indexing of the files of the whole of the technical departments.

There is practically the same organisation on the Paris-Lyons-Mediterranean (*P. L. M.*) Rys. and the *Est* Ry.

The *P. L. M.*, however, has an executive organisation, the technical division specialised in the electrical service. As far as it is concerned, this division executes the programmes drawn up by the other four technical divisions.

An improvement in the efficiency of the technical departments has also been obtained by other means, such as the regrouping of sections having duties in common so as to obviate internal correspondence and the formation of several files for one and the same matter. Thus, the staff of the commercial section (sidings, leases) of the commercial service, operation, of the *P. O.* has been attached to the technical office.

Mention will likewise be made of the use of cards for following up business and that of special printed forms. For example : The questionnaire utilised by the *Nord Railway* with a view to having on one document all the information which experience has shown is likely to come into consideration in studying a new branch line.

Circulation of trains.

Although the methods of the railways differ in detail, one can say that the circulation of trains is in general followed by means of documents drawn up daily by the enginemen and train employees, station reports and graphs of the control or dispatching posts when the railways possess the latter organisations (3).

(3) « Particularités de l'organisation des postes centraux de régulation sur le Réseau de l'Est » (Particulars of the central train control offices on the Est Railway). Massin, *Revue Générale des Chemins de fer*, April 1926.

We give below, as an example, an account of the method employed by the *P. O.* On this railway, the circulation of trains is followed in the first place by the districts by means of the train reports in which are entered the times of departure, passage and arrival at stations and the incidents on the journey and also by means of operating reports which are drawn up by the marshalling stations for each period of 24 hours and which show the delays of a certain magnitude.

The examination by the districts is duplicated by that of the central department to which the same documents are sent and which also receives the graphs of the controllers which show the causes of time losses or of the various incidents occurring.

The *Nord* endeavours to avoid memoranda, graphs, etc., and tends towards providing a direct control by a certain number of officials from the operating department who travel permanently on the railway with suitable instructions for the conditions of the traffic at the moment. However, this direct action is supplemented by a control *a posteriori*, on the following principle : The running of express and rapid trains is summarised from the report of the guard, this report being supplemented and rectified if necessary by means of information drawn up daily by the district chiefs and sent to the operating department headquarters. The running of the other trains is followed in the operating districts and by the operating department. Finally, the regularity of goods' trains is followed daily in the districts and weekly by headquarters.

Stations and passenger traffic.

Of the examples of the organisation of passenger stations which have been reported to us, we shall quote that effected at *Lyons-Perrache.*

The *P. L. M.* has been obliged to organise as rationally as possible the station in question on account of its importance.

It has in fact a daily service of 199 passenger trains, 39 of which pass through the station. The number of passengers arriving at or departing from Perrache is on the average 19 000 daily. To this figure must be added about 5 000 passengers who change trains daily. During the summer months, these figures are doubled and are sometimes five times as great at certain holiday times.

The *Perrache* station also has an important fast goods traffic (reception, despatch, transhipment).

The organisation of this station is based on a well studied distribution of the staff among the different services, this distribution being made concrete by a general table which indicates the grades of the employees as well as their chief functions and which gives the composition of the reserve gangs and the flying squads. This table has been drawn up as a document of permanent character. It is only altered in case of important changes in the theoretical list of the staff or of definite modification in the functions or the effective strength of a principal department.

The allocation of tracks and the working of the washing sheds, marshalling yards and stabling sheds are regulated by complete graphs which are revised twice a year at the time of changing the time-tables. These graphs contain all the information relating to the evolution of rakes of carriages, the conditions of reception of trains on the platform tracks, the evolution of the trains on the inspection tracks and their despatch to the marshalling sidings before washing, etc. They likewise show the extra trains which may be ordered to run. The latter are, moreover, generally received at the same platform as the regular train so as to facilitate the movement of the passengers and the service of the staff.

The strict allocation of the tracks shown on the graph is always adhered to in practice (at least in 997 cases out of 1 000), whereby it has been possible to manifold the notices indicating the arrival platform and the departure platform of the trains, this information being greatly appreciated by the passengers, and to endow the service with a stability considerably facilitating the task of the employees of all branches. Finally, the employees in charge of the work, co-operating with the traffic department, are informed by handbooks regarding the composition of the trains, the periodical strengthening, the allocation of the tracks, etc., and generally regarding all the details permitting them to supervise very closely the operations which each train undergoes. The working of the organisation is controlled by a traffic foreman.

The *Est*, on the *Vincennes* line, has created an interesting organisation, the outlines only of which will be given, since a film will be shown at the Congress on this matter (4).

As a result of the practical impossibility of enlarging the terminal station, increasing the number of tracks or again of increasing the capacity of the already fully loaded trains, this Railway has been obliged to seek the means of meeting the rapid increase in traffic in the rational organisation alone of the train workings.

Its examination has led it to deal with the capacity possibilities of the line, the specific possibilities of the station resulting from its material organisation and finally on the output obtained from the equipment of both the line and the station.

As regards the line, the block system with mechanical signals has been replaced by a block system using automatic signals, so located that the trains could follow one another at the minimum interval of one and a half minutes. By

(4) « Organisation rationnelle d'un service de banlieue » (Rational organisation of a suburban service). RABOURDIN, *Bulletin du Comité National d'Organisation française*, October 1931.

means of this simple substitution, the possibilities in regard to the capacity of the line were considerably increased.

As regards the station, efforts were made to obtain the largest possible number of simultaneous movements. In fact, in every case, it is possible to dispatch a train from one of the platform tracks while another train is entering on the track immediately adjacent.

On the line, the circulation of the trains was organised by divergent fans of sidings for trains leaving Paris and convergent fans for the trains going towards Paris. By this it must be understood that the line is divided into several zones, each zone being served in principle by a train in each fan. This train, in the up direction goes through from Paris-Bastille to the first station of the zone in question and then becomes a stopping train. In the down-direction, on the other hand, each train begins as a slow train in its departure zone and becomes a through train on leaving this zone until it arrives in Paris.

Since 1925, the following results have been obtained by means of this organisation : From 6 p. m. to 8 p. m. twenty eight trains arrive in Paris and twenty eight leave Paris as against 21 and 22 in 1924, viz., an increase of 30 % and parallel with this the carrying capacity has increased from 210 to 280 passengers per minute, which represents an increase of 33 %. Finally, during the hour of heaviest traffic, 19 000 seats are provided as against 12 000, an increase of 58 %. The regularity of the service has also been considerably increased, seeing that the average delay is 6 seconds over the whole working.

This Railway adds that, due to the abolition of the general stop which, up to 1925, applied to all arriving trains to the change in type of locomotives and to the considerable regularity existing at the present time in the service, it would henceforward be possible to despatch and receive during the evening rush hours forty trains, that is an increase of 83 % as compared with 1924 and 20 % as compared with 1925. During the hour of heaviest traffic, there would thus be provided 20 000 seats, representing an increase of 67 % as compared with 1924 and 5 % as compared with 1925. This figure could, moreover, be increased to 25 000 by reducing the interval between two arriving trains to one and a half minutes, which is the present figure for the interval between trains on departure. The *Est* adds that the examination made in view of the organisation which has just been explained has been, moreover, a useful lesson in the study of the arrangements to be made in the new Paris station which was in course of completion and which is frequented by a considerable number of suburban passengers (about 70 000 daily in either direction).

In connection with this last station, we may mention the use of a system for reducing, with steam traction, the movements necessary to bring the engine to the head of the train. Three oblique tracks pass through the whole of each suburban station. The first oblique track is for the departure of trains, the second for their arrival and the third for the temporary standing of the locomotives being shunted round.

As a rule, the locomotives pass from the track on which they are standing on to the third oblique track, immediately after the arrival of the train on to which they are to be backed. Thus, they do not interfere with the arrival of trains except during half of their movement.

The *Nord* and then the *State* have considerably increased the facility of working their suburban services by the introduction of what are called « reversible » trains, in which the locomotive always remains at the same end of the train which it pulls towards Paris and pushes from Paris. A driver's cab situated at the opposite end of the train from the engine enables the driver to control the mechanism of the engine at a distance

when the engine is pushing. In short, it is possible by means of this device to obtain with steam traction advantages similar to those afforded by electric traction. These advantages are more important for the service in stations of large towns where a large number of movements have to be made in a short time on converging tracks involving thus secant movements.

Movement and distribution of rolling stock.

The large railways of all countries take steps to follow as perfectly as possible the movements of their wagons so as to control their utilisation. They also endeavour to be able to send rapidly to a region short of wagons, the vehicles in excess in another region, that is to say, to distribute the wagons as well as possible for the needs of the traffic.

We will merely mention here the position of the problem which, moreover, forms the subject of a special question of the Cairo Congress (*Question VII*).

Generally speaking, the movement and distribution of rolling stock are followed up in the first place by what are called distribution stations or by inspectors, as is the case on the *Midi Railway* and the *Nord Railway;* who receive daily from the stations in their zone a special report which is always closed at the same time and on which are indicated in available vehicles and by the kind of wagon (covered wagons, box wagons and flats), the number of wagons present, the requirements for the following days, including the requirements for the preceding days which have not been satisfied, and finally, the surplus of vehicles available over and above the requirements. Such information is afterwards centralised by the regional departments (districts, areas or divisions) which ensure a balance between the stations of the group and send daily to the headquarters of the department a statement giving the situation as a whole in their area.

Thus, with the aid of the various returns which it receives daily regarding the situation on the railway, the headquarters are able to regulate important movements of the stock to any district whatever of the railway.

Elsewhere, the *Netherlands Railways* and the *Alsace-Lorraine*, the *Est* and the *P. O.* mention the existence of officials (inspectors or controllers) whose duty it is to check on the spot the operations of the distribution of stock.

The *Nord* employs the following method of controlling the movements of wagons :

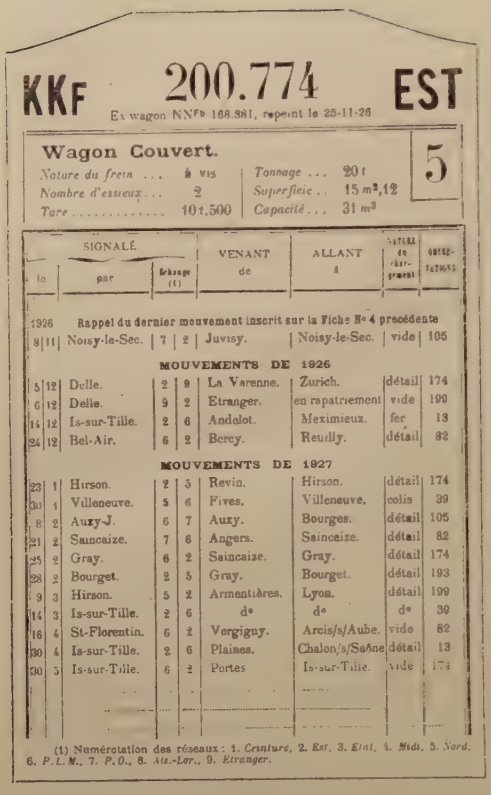
Every loaded vehicle in transit from one station to another is accompanied by a waybill. Every empty wagon, with the exception of open wagons returning to the collieries or the ports, is accompanied by a special form taken from a counterfoil book in quadruplicate, one copy remaining attached to the book, the second being sent to the distributor and the third, acting as despatch note, being forwarded by the despatching station to the destination station.

These various documents enable the last mentioned station and the distributors at the different stages to follow the movement of the wagons and to reveal delays in their transit.

We would add that, for inter-railway movements, the control and accounts of the exchange of slow traffic vehicles have been concentrated by the great *French Railways* in a single body called « *Central Wagon Movement Office* », the common use of wagons being based on the principle of compensation in kind (5), the excess of the mutual loans alone resulting in a monetary compensation.

The movements of French wagons from railway to railway are followed in this office by means of card indexes in accordance with the exchange returns

(5) Articles by Collot, *Revue Générale des Chemins de fer*, November 1927, and by Billard, *Mon Bureau*, April 1929.



KKF 200.774 EST

Ex wagon NNFo 168.981, repeint le 25-11-26

Wagon Couvert. 5

Nature du frein ...	à vis	*Tonnage* ...	20 t
Nombre d'essieux ...	2	*Superficie* ..	15 m²,12
Tare	10 t.500	*Capacité* ...	31 m³

SIGNALÉ le	SIGNALÉ par	Echange (1)	VENANT de	ALLANT à	NATURE du chargement	OBSERVATIONS
1926	Rappel du dernier mouvement inscrit sur la Fiche N° 4 précédente					
8 11	Noisy-le-Sec.	7	2	Juvisy.	Noisy-le-Sec.	vide	105
	MOUVEMENTS DE 1926						
5 12	Delle.	2	9	La Varenne.	Zurich.	détail	174
6 12	Delle.	9	2	Etranger.	en rapatriement	vide	100
14 12	Is-sur-Tille.	2	6	Andelot.	Meximieux.	fer	13
24 12	Bel-Air.	6	2	Bercy.	Reuilly.	détail	82
	MOUVEMENTS DE 1927						
23 1	Hirson.	2	5	Revin.	Hirson.	détail	174
30 1	Villeneuve.	5	6	Fives.	Villeneuve.	colis	39
8 2	Auxy-J.	6	7	Auxy.	Bourges.	détail	105
21 2	Saincaize.	7	6	Angers.	Saincaize.	détail	82
25 2	Gray.	6	2	Saincaize.	Gray.	détail	174
28 2	Bourget.	2	5	Gray.	Bourget.	détail	193
9 3	Hirson.	5	2	Armentières.	Lyon.	détail	199
14 3	Is-sur-Tille.	2	6	d°	d°	d°	39
16 4	St-Florentin.	6	2	Vergigny.	Arcis/s/Aube.	vide	82
30 4	Is-sur-Tille.	2	6	Plaines.	Chalon/s/Saône	détail	13
30 5	Is-sur-Tille.	6	2	Portes	Is-sur-Tille.	vide	174

(1) Numérotation des réseaux : 1. *Ceinture*, 2. *Est*, 3. *Etat*, 4. *Midi*, 5. *Nord*, 6. *P.L.M.*, 7. *P.O.*, 8. *Als.-Lor.*, 9. *Etranger*.

Fig. 3 — Model of card used by the Central Wagon Movement Office

Explanation of French terms:

Ex. wagon N... repeint le... = From wagon N... repainted the... — Wagon couvert = Covered wagon. — Nature du frein... à vis = Type of brake... screw. —Nombre d'essieux = Number of axles. — Tare = Tare. — Tonnage = Tonnage. — Superficie = Area. — Capacité = Capacity. — Signalé le... par... = Reported the... by... — Echange (1) = Exchange. — Venant de... = Coming from... — Allant à... = Going to... — Nature du chargement = Loaded with. — Observations = Remarks. — Rappel du dernier mouvement inscrit sur la fiche n° 4 précédente = Note of the last journey inscribed on previous card No. 4.
Mouvements de 1926... de 1927 = Movements in 1926... 1927. — Détail = Miscellaneous goods. — Vide = Empty. — Fer = Iron. — Colis = Packages.

(1) Numérotation des réseaux : = Numbering of the railway systems.

arriving daily from all the interchange stations between railways. Each wagon of the French railways is represented by a card of a different colour for each of the railways and of a special form according to the kind of wagon. On each card is entered all the information provided by the stations regarding the movements of passage from one railway to another and regarding the operations special to each wagon (stop, repairs, transhipment, etc.); see figure 3, showing the reproduction of one of these cards.

The parcels of returns arriving at the office contain about 5 600 documents from the interchange stations. About 45 000 entries have to be transferred to the cards daily. The cards are filed in card indexes to the number of 30 (fig. 4) and everything accessory has been done as regards surroundings to provide the employee with the best working conditions. In this way, an average of 145 entries per hour is attained.

The real values as to utilisation of the vehicles offered by the various railways are taken into account by assigning to them coefficients based on the comparison of their dimensions and loads with those of an imaginary vehicle called the « unit vehicle ».

The *Central Wagon Movement Office* has also to make out and check the accounts for exchanges with foreign countries for each of the French railways which are individually affiliated to the union governed by the R. I. V.

The *North of Spain* has an office organised in the same way as the Central Wagon Movement Office which we have just described above briefly.

The *Belgian National Railway Company* controls the movement by means of statistics, in the form of graphs relating, more particularly, to the nature of the transport, the traffic at the frontier points and finally the imports and exports from ports, etc. On this railway, the allocation of the rolling stock is effected in accordance with a plan based upon the despatch by permanent movements evacuating the surplus of vehicles of the intermediate stations towards the

Fig. 4. — The Central Wagon Movement Office.

concentration stations, despatch by constant or regulated movements feeding the surplus vehicles of concentration stations towards the distribution stations and finally despatch by constant or regulated distribution movements of the surplus vehicles of the distribution stations towards the using stations.

This plan is put into use by means of diagrams relating particularly to the number of the wagons of the railway received loaded in the destination stations, to the number of wagons returned empty to the points of exchange, to the numbers of foreign wagons used and of the wagons asked for, and finally relating to the estimates of the supplies, of the actual supplies and of the surplus wagons.

Shunting and marshalling goods trains.

From the technical standpoint, and irrespective of the means employed, shunting consists in re-assembling the wagons of a given train in an order differing from that in which they existed previously.

In short, therefore, the problem is to impart to the different wagons to be shunted a direction and velocity such that they reach the new position assigned to them and also to adjust this velocity so that the wagons will not cause damage by running too violently into those already in position. It is also necessary to avoid back working wagons and to prevent wagons fouling when running through the points.

When we remember also that some sta-

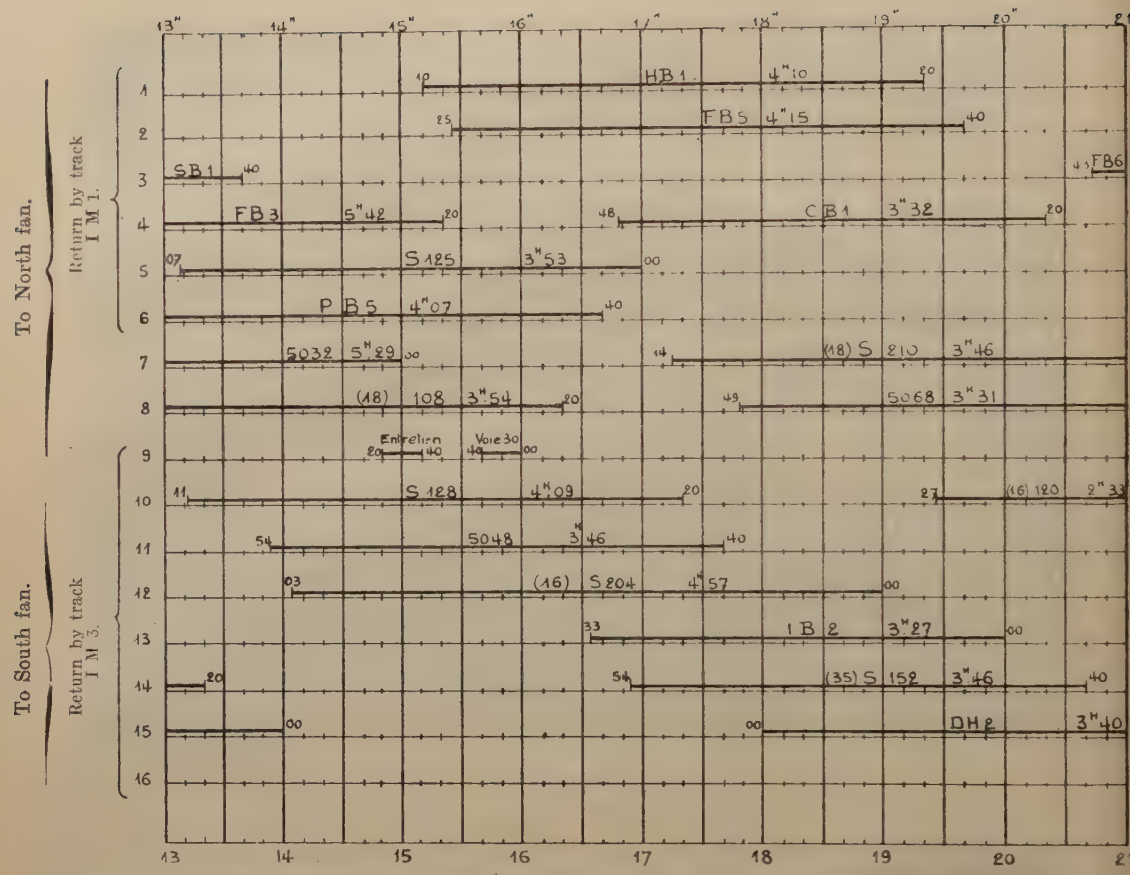


Fig. 5. — Est Railway. — Blainville shunting yard. — Diagram of occupation of lines in arrival fan.

Note: Entretien — Maintenance. — Voie 30. — Track No. 30.

tions receive up to 6 000 wagons daily, we can judge of the importance of the work shunting involves and the advantage to the railways of organising methodically the yards where this work is done.

Of the Railways interrogated, the *Est* has provided us with particularly detailed information and as an example we shall give the steps taken by this railway in the station of *Blainville* where the three stages of shunting : preparation, execution and control, have each been the subject of a very thorough investigation.

The preparatory work consists in the exact indication of the duties of each person. For this purpose, duty lists, rules or orders are drawn up, as well as graphs of the circulation and occupation of the arrival and marshalling tracks and finally diagrams showing the means to be employed (locomotives, tractors, speed of shunting) in terms of the temperature and the traffic.

Figure 5 is a reproduction of a theore-

tical graph showing the allocation of the reception tracks.

In order to carry out the work, numerous and appropriate means of communication (telephone, loud-speakers, luminous panels, etc.) have been placed at the disposal of the employees. Some of these devices, such as three-light signals providing communication between the foreman shunter and the driver and multiple indication devices with delayed effacement for the communication between the foreman shunter and the pointsman enable shunting the operations to be carried out with a reduced staff. The signaller who announced the wagons to the pointsman, the fireman and the operating employee who accompanied the driver have been dispensed with.

Moreover, electrical shunting boxes by means of which the pointsman prepares the entire route of a given wagon, this route being opened automatically in front of the wagon concerned as fast as it is released by the preceding wagons, have made it possible to dispense with 25 employees while assuring the operation of the points under the best conditions.

The wagons having been sent on their way, they are slowed down and stopped by the means usually employed (hand brake mounted on the vehicles, hand operated slipper brakes) and besides by devices operated by remote control. The use of these retarding devices has enabled the rate at which wagons are shunted to be increased from three to four wagons per minute to eight or ten wagons.

Finally, in order to bring into contact with the wagons previously stopped those wagons which stop short, petrol tractors running in the six-foot way are employed instead of shunting locomotives (6), this giving a reduction of 30 % in the number of hours of use of the locomotives and an annual saving of about 500 000 francs.

The wagons are coupled up by means of the shunter's pole. This implement which renders it unnecessary for shunters to go between the buffers of wagons was invented by an engineer of the *Nord* and is also in use on this Railway. A film on the use of this pole will be shown at the Congress.

The various operations having been completed, the output is checked in the first place by comparing the various graphs of the actual happenings with the corresponding graphs of the expected output and in the second place by the graphs showing the employment of the shunting locomotives and tractors and by the papers necessary for determining the bonuses of the employees.

We give herewith two graphs which fix as a function of the temperature, one the number of wagons which may be shunted with two locomotives and the other the retardation which must be effected in the shunting speed of the wagons (figs. 6 and 7).

The *Est* states that, due to these different measures, the annual economy realised at this one station of Blainville is 1 300 000 francs.

A film of the organisation just described will be shown at the Congress.

Other Railways have also directed their efforts to the organisation of shunting yards.

The *Belgian National Railway Company* has taken steps to determine the braking distances of vehicles with a view to obviating either premature stoppage of the vehicles or excessive shocks against the rakes already formed. Consequently, this Company has made a study of the hump profiles and has put into force shunting orders and braking instuctions forming a train shunting programme which is as exact as possible.

In the principal stations, this Company has created a post of « Station Controller » who in combination with the line

(6) Rabourdin, *Revue Générale des Chemins de fer*, November 1928.

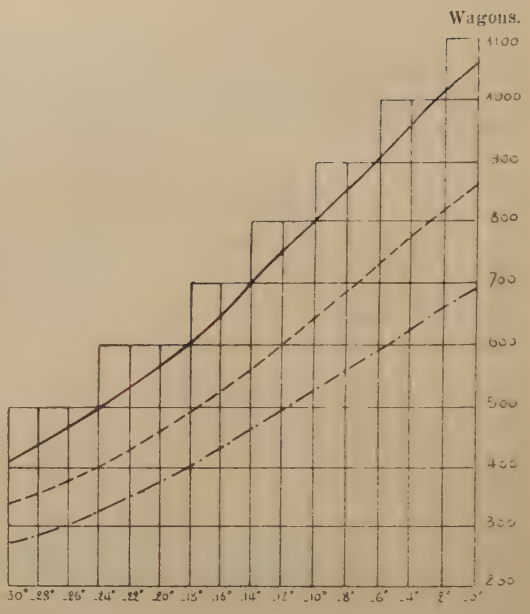


Fig. 6. — Shunting yard at Blainville, French Est Railway. Number of wagons that can be shunted with 2 locomotives, in relation to the temperature.

Output.	Coefficient of economy.
100 %	35
Normal	Normal
65 %	0

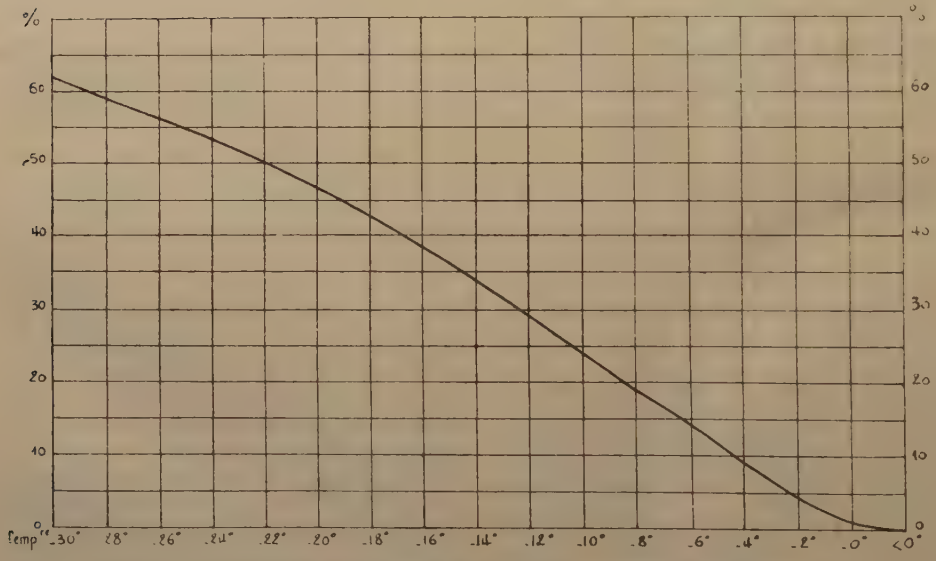


Fig. 7. — Reduction to be made in the shunting speed of the wagons in terms of the temperature.

controllers directs all movements on the station tracks, supervises the extent to which goods trains are utilised with a view to reducing their number and finally is employed in utilising the existing resources : locomotives and train employees, to the best advantage.

The *French State Rys.*, as the result of a very thorough examination, have established « General Operating Orders » which fix for each station the function of the various shunting organisations, the magnitude of the work which has to be done there and the expenses which may be involved in terms of the traffic. This measure, as well as the creation of control posts in shunting yards has enabled the movement of rolling stock to be increased by 17 % and the expenses for shunting locomotives and staff to be reduced by about 22 %.

The *Nord* utilises shunting inclines wherever the ground permits it so as to effect shunting by gravity without shunting locomotive. Uncoupling is done by means of the pole, and scotching is effected by means of slipper brakes which in some stations are electrically controlled from a cabin. All movements of wagons, from their arrival to their departure, are carried out in one direction only, without shunt-backs or crossing loops. The exchange of locomotives between the depot and the arrival and departure lines is done on independent tracks with a special direction of circulation.

The *Midi* has reorganised the shunting station of *Bordeaux-Saint-Jean*, the efficiency of which is followed up by means of very complete statistics. The staff are interested in the output by means of premiums.

As regards more particularly the means utilised for regulating the speed of shunted vehicles and to ensure their travelling over the tracks of the various yards, we would remind the reader that reports were submitted on this subject on the occasion of the *Madrid* Session (*Question X*).

Handling goods.

In what follows we shall give an account of the organisation established by the *Midi* at the *Bordeaux-Saint-Jean* goods station for handling slow parcels traffic. These goods comprise those being despatched, those arriving and finally those which are transhipped.

Attention was first turned to reducing the tonnage handled to that strictly indispensable. This reduction which could not be effected either on the goods despatched or on those arriving but only on the goods transhipped, was obtained by the application of special preliminary measures.

The staff for handling goods is divided into two groups and each of these groups in turn comprises squads composed of a foreman and three gangs: two gangs of « wheelers » and one gang of « loaders ».

The preparation for the work consists in going through the documents from the wagons. This work is done by the foremen.

In the transhipment sheds, the assistant clerk enters on a slate hooked on each wagon the size and destination of the lots contained in each wagon.

The individual efficiency of the staff has been improved by selecting the employees and by granting efficiency premiums.

In addition, efforts have been made to improve the working conditions of the men. With this end in view, the lighting has been improved, particularly by the use of portable hanging lamps which can be placed in the wagons. Numerous telephones have been installed in the various sheds to avoid movements of the foremen. The sheds have been equipped with electric trucks and cars carrying 1 000 to 1 200 kgr. (2 200 to 2 640 lb.) as well as special appliances suitable for handling bulky packages. Finally, a type of loading gangway which is light,

robust, steady and non-slipping has been designed.

The improvement in the efficiency resulting from the application of the measures described above from 1927 to 1931 is greater than 30 %.

The *P.O.* at *Juvisy* has perfected an organisation answering the same purpose as that described above. The work is distributed over two periods. During the first period extending from 4 a. m. to 4 p. m. the rakes of loaded wagons are brought to the platform and loading and unloading of the full wagons is carried out. From 4 p. m. to 8 p. m. the parcels left intentionally on the platform after being unloaded are loaded into goods collecting wagons. The number of gangs required for handling the goods is fixed beforehand on the basis of the tonnage of the wagons.

Sorting and classifying is facilitated by entering on each lading bill the number of the wagon or of the bay in which the parcel is to be placed, and for the goods collecting wagons, the number giving the order of loading of the parcel into the wagon corresponding to that of the stations to be served is indicated.

This organisation is supplemented by an improvement of the necessary equipment: handling equipment (tractors, trucks, etc.) and office equipment (adding machines, wall tables, improved card indexes, etc.).

Rolling stock and locomotive running department.

Organisation of the technical offices.

The designs offices of the rolling stock and locomotive running department have to make all the drawings concerning the locomotives, rolling stock and the fixed plant affecting this department. Altough the nature of the work carried out in these offices, being purely intellectual, renders extremely delicate the application of ordinary work organising methods, it is possible to discover means which are capable of increasing more or less directly the efficiency of these offices.

The *P.O.* has given an account of how it re-organised the designs offices of the rolling stock and locomotive running department.

The steps taken comprise essentially :

— speeding up the work of searching for useful documents, particularly drawings, by the use of card indexes: indexes for stocks of drawings, information indexes (articles in periodicals), etc.

— facilities for following the state of progress of the various schemes by keeping up to date a wall diagram on which each scheme is represented by a movable coloured marker, the position of each marker in the columns of the diagram providing information regarding the state of progress of the scheme.

— finally, the possibility of knowing the cost of each scheme from information provided on individual cost sheets furnished by the draughtsmen. This method of book-keeping which provides a cost for each scheme has been found to be very useful in order to check the work of the draughtsmen and to know subsequently, by comparison with previous schemes, the probable cost of a scheme which has to be made.

Each scheme is given an order note bearing the brief title of the work to be undertaken as well as the number of the order. These order notes must be approved by the departmental head who alone has power to authorise the starting of a scheme.

In order, as far as possible, to relieve the heads of the different subdivisions of the drawing office (locomotives, carriages, wagons, fixed plant) of work which is not properly speaking research work, a supplementary section has been set up which is in charge of special work such as orders, statistics, checking of drawings, copying documents and more generally the centralisation of work common to several subdivisions.

Driving of locomotives.

A rational organisation of the work of driving locomotives ought to aim at allotting to the trains the locomotives which are best suited to their difficulty of working and their nature and also to obtain a maximum daily run for the locomotives and locomotive men.

The choice of the locomotives to be allocated to the various services and consequently the schemes seeking to improve locomotives is outside the scope of the present report, and we shall therefore confine ourselves to analysing the replies which we have received in regard to the second point, i. e. the efforts to obtain the maximum possible daily runs from the locomotives and enginemen.

Two methods are employed by the railways for the utilisation of the locomotives. Firstly, there is the method employed generally by the British railways in which the locomotives are not assigned to any particular set of men and secondly the method which appears to be generally employed in the other countries included in our report and which consists in assigning the locomotives to definite sets of men.

The choice of the railways between these two methods appears to have been decided by looking for economies resulting either from the reduction of the number of locomotives in service (locomotives in general use) or from the better upkeep of the locomotives and economies in the cost of coal (locomotives assigned to regular men).

Those railways which assign locomotives to regular men endeavour, moreover, to obtain satisfactory utilisation of the locomotives by doubling or even sometimes tripling the sets of men working the same locomotive.

Then again, the effective working period of the regular men may be increased by relieving them of all work in the sheds. Such practice cannot be generalised without losing some of the advantages to be anticipated from the assignment of locomotives to regular men.

In addition, several railways have realised a considerable saving in staff by employing one engineman when working light trains or when shunting.

The service of enginemen working scheduled trains is regulated almost everywhere by traffic orders which may be as perfected as possible. The difficulty is greater when we come to the question of special trains. Generally speaking, efforts are made to reduce to a minimum the staff employed in working these trains while taking into account the necessities of the service. Several railways have obtained interesting results by entrusting the ordering of special trains to the control staff.

Finally, efforts have been made in a general manner to increase as far as possible the distances travelled in one stage by the enginemen.

The *P. L. M.* gives the following stages :

Paris-Vichy . . .	372 km. (231 miles).
Lyons-Marseilles .	351 km. (218 miles).
Avignon-Nice . .	344 km. (214 miles).
and the *Nord :*	
Paris-Liége . . .	367 km. (228 miles).

Among the examples given by the British railways, special mention should be made of the *London & North Eastern Railway* (*L. N. E. R.*), which runs without intermediate stop from King's Cross to Edinburgh (393 miles) with a change of enginemen during the journey, this being made possible by the provision of a corridor through the tender.

The *New South Wales Government Railways* make their locomotives, which are driven by three sets of men, cover daily a distance of 690 km. (430 miles) in the case of passenger trains and 430 km. (267 miles) in that of goods trains. The men are changed at intermediate stations, and fires are cleaned during the journey.

On the same lines, the *Belgian National Railway Company* mentions that, by

employing three crews, it has been able to increase the average daily mileage of certain workings to 435 km. (270 miles) in the case of international trains and 284 km. (176 miles) in the case of long-distance goods trains.

The foregoing relates especially to steam traction, but it may be applied in the case of electric traction with this difference that the latter form of traction affords incontestable advantages from the point of view of the utilisation of the driving staff and of the locomotives, particularly by dispensing with the time required for the preparation of the engine and lighting up.

The *P. O. Railway* mentions an express train working utilising three high-speed electric locomotives with two sets of men, enabling an average daily run of 691 km. (429 miles) to be attained with these locomotives.

Locomotive depots.

The operations carried out in the locomotive depots are divided into movements of locomotives, handling of coal, and ordinary repair work. All railways have endeavoured to improve these various operations as far as possible.

In regard to the movements of locomotives, the standard depots, plans of which have been sent us by the *Nord* Railway, comprise at the incoming end inspection posts, generally covered in and provided with inspection pits amply illuminated from below, pits for the mechanical removal of cinders, coaling plants, stand-by tracks where the locomotives are kept while awaiting the time for departure, facilities for turning (turntables or triangles) and finally pits for cleaning the fires before departure. The locomotives run through these various posts in the order in which they have been enumerated. Water columns and sand-loading facilities are provided at convenient points on this journey. The locomotives run on independent tracks the direction of running being specially laid down.

Numbers of other Railways, such as the *L. N. E. R.*, the *Eastern Bengal Railway*, the *Belgian National Railway Company*, the *French State*, the *Est*, the *P. L. M. (Algerian lines)* mention similar arrangements. In general, the movements of the locomotives in the depots are carried out by special sets of men, so that the points where the locomotives are taken over and given up by these men should be fairly close to one another in order to avoid loss of time between the movements.

The *Belgian National Railway Company* allows time for the majority of these operations.

The *London Midland & Scottish Railway* (*L. M. S. R.*), on the contrary, states that it endeavours, to have all these movements done by enginemen proper.

The coal is handled by mechanical plant of different types which generally handle mixtures previously prepared, either in the yard adjoining the depot or in general yards at different points of the railway. The present tendency is to utilise more and more general stock yards for these purposes.

There appears to be some advantage in providing special places for the ordinary upkeep repairs in the vicinity of the stores or a small repair shop, comprising one or two covered places. In a number of railways, the time passed in making these routine repairs is controlled by granting contract times to each works per type of locomotives based on the actual mileage run.

The more important repairs, particularly the periodical locomotive repairs are made by some Railways, particularly the *French* and *Belgian* Railways, in the depots themselves, while only the heavier repairs are done in the workshops.

The Railways who carry out these repairs in the depots have taken different methods for increasing the output efficiency. Thus, fixed times have been put

into force, the best methods of working and the progressing of the operations through the workshop have been investigated systematically, etc. These methods are similar to those in use in the main workshops, although they are generally simplified. They will be described later. The efforts to improve the efficiency of the depot workshops often result either in the abolition of certain depot workshops which are insufficiently equipped, or to the specialisation of certain depot workshops for the overhaul of definite types of locomotives. In this case, the various depots no longer undertake the repair of their own locomotives and the depot workshops come to be considered as organisations which are independent of the depots themselves.

Inspection and cleaning of passenger carriages.

The inspection and cleaning of carriages are carried out at the terminal station. When the number of rakes to be cleaned in a day becomes sufficient, it is essential to consider the organisation on rational principles of suitable yards. Various Administrations have described these improved yards.

By way of example, we shall give a description of the yard at Bercy-Conflans of the *P. L. M.* which comprises :

1. A fan of arrival sidings composed of ten tracks on which are stationed the trains cleared by the Paris station, after they have been inspected summarily in that station with a view to discovering serious damage, more particularly hot axle boxes, and two inspection tracks provided with pits for the detailed inspection and the lubrication of the vehicles. (The necessary materials for repairs decided upon in the course of this inspection are ordered at once through a special office).

2. A washing machine.

3. A washing yard comprising eleven tracks, nine being covered, in which cleaning and repairs are completed. The interior upholstery is cleaned by means of portable vacuum cleaners.

4. A fan of marshalling sidings of 15 tracks.

5. Finally, a fan of stand-by sidings on which the rakes are placed before they are sent to the station.

A final inspection is made before departure to see if the work has been done satisfactorily.

The rakes are run through the various installations in accordance with a graph. The number of vehicles cleaned is 500 daily.

We do not intend to enlarge on the description of the train washing machine, which is known on all Railways and the use of which has also been mentioned by the *L. N. E. R.*, and by various French Railways (*Est, State, Nord, P.-O.*). The *Est* estimates at 600 000 francs annually the economy resulting from the use of such a machine in the yard at *Paris-Ourcq*.

Inspection of goods wagons.

These operations have been the subject of systematic investigations on the part of the majority of the railways with a view to speeding up the work and to reduce the time occupied. The *Est* in particular explains the principles which were used when organising the inspection of vehicles in its shunting yards: a shunting yard comprising in principle three groups of sidings :

— arrival sidings;
— shunting sidings;
— marshalling sidings;

to each of which there is assigned a group of inspectors who are specially trained in detecting well-defined types of damage.

The inspectors of the arrival sidings make a complete inspection with a view to stopping immediately the damaged wagons, as well as those which are to proceed to the shops for overhaul, alterations, etc. The inspectors of the shunting sidings note the damage which may have been produced during the

shunting operations. Finally, the inspectors of the marshalling sidings look for damage which may have been produced during the marshalling operations, but only such damage as is likely to affect the safety of running.

A considerable advantage of this method is to reduce the number of defective wagons taken out of the trains prior to departure and hence to reduce the delays of trains on departure.

This method was applied in 1929 at the marshalling yard of *Blainville* and has been extended since 1930 to other marshalling stations on the Railway.

Maintenance of goods wagons.

The repairs carried out at the current repair sidings consist entirely of ordinary rolling stock repairs. The heavy and systematic repairs are carried out in the main workshops.

The main difficulty which arises in organising the current maintenance repair work is the diversity of the repairs which have to be made, a diversity not only of the nature of the work but also of the importance of the repairs.

In the organisation of the work of the maintenance shops there is a general tendency to approach as closely as possible the « belt » or progressive line method of working, the vehicles moving in covered sheds in front of the various gangs of workmen.

In order to make it possible to employ the belt method of working, it is necessary first of all to sort the wagons into several groups according to the nature of the repairs. At the Juvisy maintenance shop, the *P.-O.* divides its wagons into three groups :

— Those which will take between ten and thirty working hours to repair.

— Those which will take between thirty and sixty working hours.

— Lastly, those which will take longer than sixty working hours.

The *Nord* works in a similar manner in its maintenance shop at *Aulnoye*. The *Est* works in a different manner : the vehicles are sorted according to the nature of the repairs.

All the Railways who have systematised the work on these principles, endeavour to supply spare parts rapidly and easily. For example, the *Nord* makes use of store wagons which travel on the arrival inspection tracks and from which the spare parts are taken to assemble them directly on the damaged wagons.

Lubrication of vehicles, which is generally carried out in transit stations, has been systematised by some Railways.

The *P. L. M.* (*Algerian Lines*) states that the periodical lubrication of vehicles takes place every three months and that the lubricator pads are checked every six months. The saving in oil by applying this method is 50 % and the reduction in the number of hot boxes is also 50 %.

Main workshops.

We have received numerous detailed replies in connection with the organisation of the main workshops of the Railways. In fact, the main workshops offer greater facilities of organisation than the majority of the other establishments of a railway.

Efforts have been made by the Railways to employ in their main workshops modern methods for the organisation of the work as if these shops formed an independent industry.

The first step of a general character taken has been the reduction in the number of workshops and the specialisation of each of the workshops retained for the repair of certain types of locomotives, carriages and wagons. In most cases, efforts have been made to apply belt or progressive line methods of working, although it is relatively more difficult to employ such methods for repairs than for new work.

Of course, the belts or progressive lines are not absolutely the same as those to be met with in certain industries, for example, the motor car industry. In

fact, the weight and dimensions of the locomotives or rolling stock are much more considerable, the number of operations is greater and the rate of movement is necessarily slower.

Some Railways mention the existence of secondary belts for the repair of constituent parts of locomotives, carriages or wagons. However, the use of such belts is not yet general. In most workshops, it is preferred to keep the machine tools for less specialised uses so that they can be employed for orders of a general character, for example, for store supplies.

The use of general rational methods in the workshops likewise implies investigations to discover the best methods of working. Such investigations necessitate the formation of special departments for improving the tool equipment and for timing the work. On the other hand, the progress of the work should be followed very closely and this condition implies the formation of departments specially responsible for following up this question. The investigations to be made by these last-mentioned departments will deal with the maintenance of stocks in the stores, the arrival at the desired time in the workshops of the material necessary for repairs and with the distribution of such material at the different points of use. A start in the rational organisation of their workshops has been made by the railways by the formation of such departments and by the application of the principles of the functional grading of the staff.

The distribution of the specialised controlling staff varies on the different railways, and in the following we shall give the general principles which have been reported to us by a large number of railways, together with the results they have obtained.

The *Belgian National* Railway Company apply the principles of specialised control in their locomotive shops. The methods of working have been systematically revised, and the belt method of working has been organised for the boiler repairs. The time required for repairing a locomotive is at present 35 working days (7) for the most complicated case.

The three rolling stock workshops retained by this railway have been specialised : one for covered rolling stock and flat wagons, the second for open rolling stock of all tonnages with steel bodies and the third for open rolling stock of small tonnage with wooden bodies. In each workshop, the organising office comprises :

— One division in charge of the inspection of the stock on arrival.

— One division in charge of the progress on the belts.

— One division in charge of control.

— One division in charge of the manufacture (tools, time fixing). (8).

Remarkable results have been obtained in the Belgian shops by the application of the belt method to the repair of wagons. It has been possible by forming two repair belts for two types of covered vehicles to increase the output by 45 % without consequent modification in the effective strength, and the combination of the two belts into a single belt has rendered possible a saving in staff of 15 % for the same output. The duration of the stages is only one hour. The difficulty arising from the fact that two types of wagons are dealt with is met by taking these types in hand alternately month by month.

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(7) The new organisation of the central workshops at Salzinnes (Namur), *Bulletin of the International Railway Congress Association*, December 1929.

(8) « Note sur l'organisation dans les Ateliers de la Société Nationale des Chemins de fer belges » (Note on the organisation of the workshops of the Belgian National Railway Company), by N. Rulot. Lecture given before the Belgian National Committee for Scientific Organisation, on the 28 May 1931.

As regards carriages, belts have been instituted for replacing gas-lighting by electric-lighting. Due to this fact, the costs have been reduced by 50 %.

The *Great Western Railway* (England) has reduced considerably the time spent on locomotive repairs in its shops by systematically revising the methods of working and by forming a progressive department (9).

The *L. N. E. R.* by employing rational methods of working in their locomotive shops at Doncaster which may be taken as typical, have reduced the number of their gangs from 16 to 12, the number of locomotives in repair from 100 to 36 and the repair time from 60 to 23 working days.

The *L. M. S. R.* for a number of years has been engaged in reorganising its wagon repair shops at *Newton Heath* (10), *Derby* (11), *Earlstone, Wolverton* and *St. Rollox* and their locomotive repair shops at *Crewe* (12), *Derby, Horwich* and *St. Rollox.*

The *Newton Heath* wagon shops have applied the principles of the belt method of working to the construction of standard steel frame wagons. One of the particularly interesting methods of work consists in the use of special devices for holding the pieces to be connected together with a view to eliminating assembly bolts as far as possible. The chief operation of the belt is riveting which is done by means of hydraulic riveting machines. The belt is in a straight line and its daily production is 10 wagons.

We shall enlarge more particularly on the organisation of the *Crewe* locomotive shops.

Formerly, these shops comprised nine different erecting shops which have been reduced to a single shop in which the construction and the repair of locomotives are done by the belt method. Four belts have been formed, each turning out one locomotive daily.

The locomotives are moved by means of overhead travelling cranes during the first days of assembling. Later, when the wheels have been put in position under the locomotives, the latter are drawn by means of a winch. The belts move forward at fixed times. In order to ensure that the fitters have all the parts they require, a schedule has been drawn up for each type of locomotive, showing the parts to be supplied at the various stages of the belt.

The production of the Crewe shop is directed by a special office which supervises both the execution periods and the control of the operations.

The shop repair programme is made out beforehand after the inspection of the locomotives so as to enable the principal spare parts to be available.

After the locomotive has been taken down in the shops, the parts are listed with a view to determining in detail the repairs which have to be done on them. For this purpose, the limits of wear for the various parts have been carefully fixed.

The application of the above-described methods and the use of spare boilers has enabled the period of repairs in the shop to be reduced from 50 to 12 days and the monthly production to be increased from 90 to 115 locomotives.

The outside shops, other than the erecting shop, have also been subjected

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(9) Boiler shop developments at Swindon Works, Great Western Railway, *Railway Engineer*, February 1929.

(10) New wagon building layout at Newton-Heath, *Railway Engineer*, March 1930. — Progressive railway carriage lifting and repairing (at the same shops), *Bulletin of the Railway Congress*, December 1927.

(11) Developments at Derby carriage and wagon works, *Railway Engineer*, October 1929.

(12) Reorganisation of the Crewe locomotive works, *Railway Engineer*, July 1928 to May 1930, and *Bulletin of the Railway Congress*, August 1928.

to similar investigations. The machine tools of these shops have been grouped so as to reduce handling to a minimum. In addition, efforts are made to work as much as possible on the belt system and the parts have been made interchangeable by the use of manufacturing tolerances.

The fireboxes and boilers of the locomotives are assembled on special lines.

The *Alsace-Lorraine* mentions the use of belts for the repair of locomotive tubes, air pumps, triple valves and heating couplings, the fitting of brakes to the goods wagons and the repair of the covered wagons and of one type of locomotive.

The *Est* has instituted work organising offices in its specialised depot workshops and in its locomotive, carriage and wagon shops. These offices comprise sections for preparing the work, drawing offices, works offices, order and control offices (13).

Details regarding the repair belt for triple valves as carried out in the shops of *Noisy-le-Sec* will be found in figures 8 to 19.

The *French State* has reorganised three typical shops (locomotives, carriages, wagons) and has divided its specialised services into production services and technical services. These services comprise a time fixing office, a valuation office, a materials office and a control office. The technical services deal with the maintenance of the plant and tools and the design of new tool equipment with a view to improving the working methods (14).

At *Hellemmes* (15), the Nord has applied a functional system of management consisting of an office for the preparation of the work, a tool maintenance section, a handling and control section and a work order distribution and execution section.

Interesting applications of the belt system of working have been made in the workshop in the case of the repair of brake gear and the maintenance of air brake pumps and locomotive feed pumps.

The new organisation of the foundry is based on a study of the manufacturing cycles and on the application of the Hymans method of continuous control, and has enabled the production to be increased by 19 % while reducing and rendering consistent the delivery times.

The *P. L. M.* distributes the control of the locomotive shops in a production office (progress), a locomotives technical office (survey and control) and a shop technical office (working methods, tools). The improvement in the working methods in the rolling stock shops has resulted in a reduction of 25 % on the former time. The duration of the repair of a wagon has been reduced from

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(13) « Revision générale du matériel P. V. » (General repair of goods wagons) (*Mohon* shops).

« Revision des bogies de voitures » (Repair of carriage bogies) (*Noisy-le-Sec* shops).

« Réparations des demi-accouplements de chauffage et de frein » (Repair of heating and brake pipes couplings) (*Noisy-le-Sec* shops).

Revue Générale des Chemins de fer, June, August, December 1930.

(14) « Note sur l'atelier central de réparation du matériel roulant électrique des Chemins de fer de l'*Etat français* », par Hyver, and « Note sur les Ateliers de réparations de locomotives des Chemins de fer de l'*Etat* à *Sotteville* », par Renaud (Note on the central electric rolling stock repair shop of the *French State* Railways, by Hyver, and note on locomotive repair shops of the *French State* Railways at *Sotteville*, by Renaud), *Revue Générale des Chemins de fer*, October 1928.

(15) Note sur la visite du 24 juin 1931 aux Ateliers d'*Hellemmes* (Note on a visit to the *Hellemmes* Shops on 24 June 1931) (Union des Industries métallurgiques et minières), and March 1929 number of the *Bulletin de l'Association technique de fonderie*.

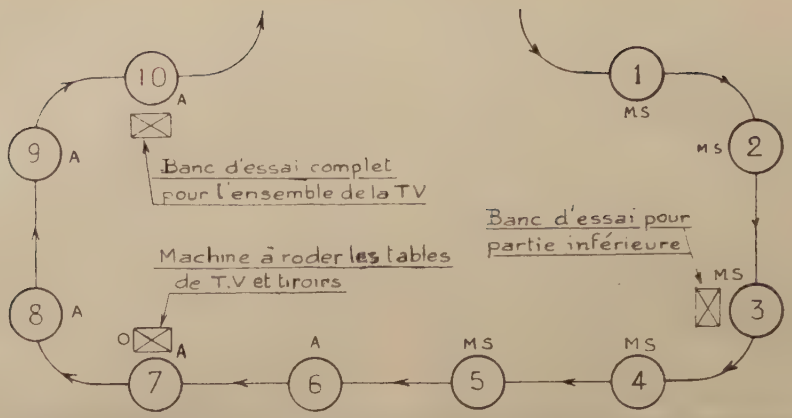


Fig. 8.— French Est Railway.— Noisy-le-Sec Shops. Repairs of quick-or slow acting triple valves, on the belt system.

Explanation :

(1)— Taking apart.
Stripping.
Cleaning lower part.

(2)— Cleaning and grinding in the stop valve.
Cleaning and grinding in the stop cock.
Cleaning loose parts, lower part.

(3)— Assembling lower part.
Checking tightness of the lower part and of the stop valve.

(4)— Taking apart parts of the cover.
Cleaning and checking parts of the cover.
Putting the cover together again.
Taking down parts of the body.
Cleaning triple valve body.

(5)— Cleaning and repairing details of the body (secondary piston and valve).
Replacing No. 16 washer.

(6)— Cleaning main piston.
Checking centring of the main piston.
Preparing body for grinding.
Grinding seat of piston on the body.

(7)— Trimming up port face and slide valve by machine.

(8)—(9)— Grinding slide valve on port face.
Greasing up.
Reassembling.

(10)— Checking triple valve.
Tests for tightness.
Tests for sensibility.
Tests for working.

Note : Banc d'essai complet, etc. = Complete test rack for the complete triple valve. — Machine à roder, etc., de T. V. et tiroirs = Machine to grind the triple valve parts and the slide valves. — Banc l'essai pour partie inférieure = Test rack for lower part.

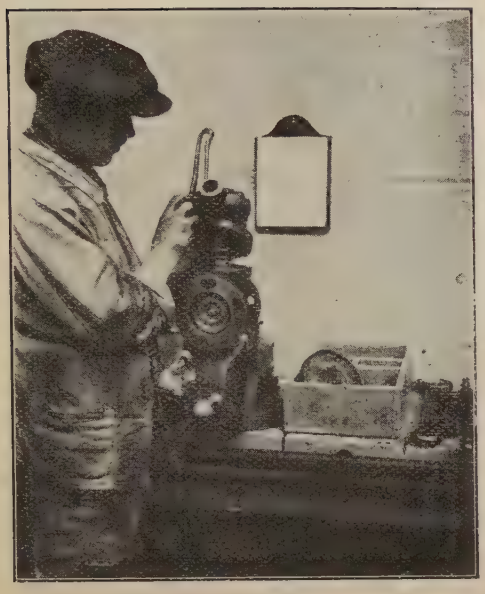


Fig. 9. — 1st phase: Taking triple valve apart.

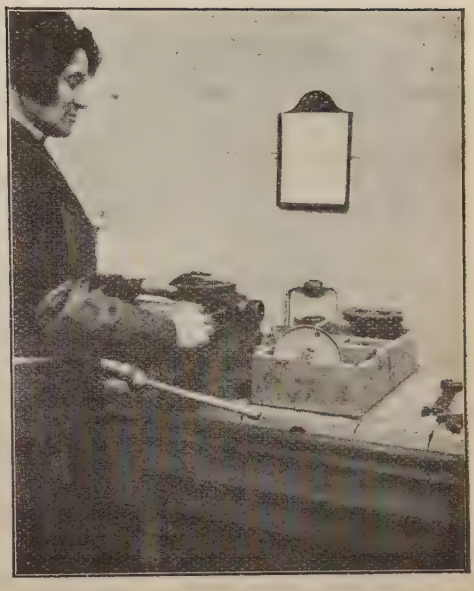


Fig. 10. — 2nd phase: Cleaning and grinding stop cock.

Fig. 11. — 3rd phase: Re-assembling lower part.

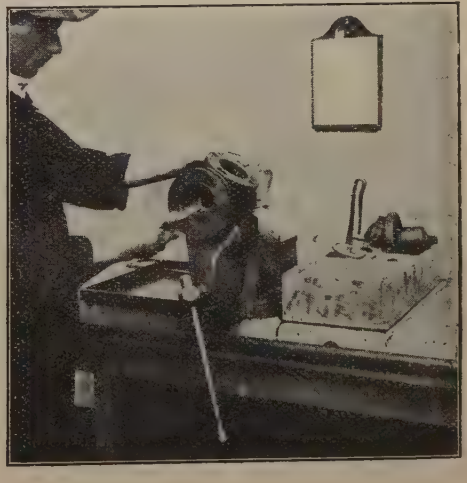


Fig. 12. — 4th phase: Cleaning body.

Fig. 13. — 5th phase : Replacing No. 16 washer.

Fig. 14. — 6th phase : Checking centering of main piston.

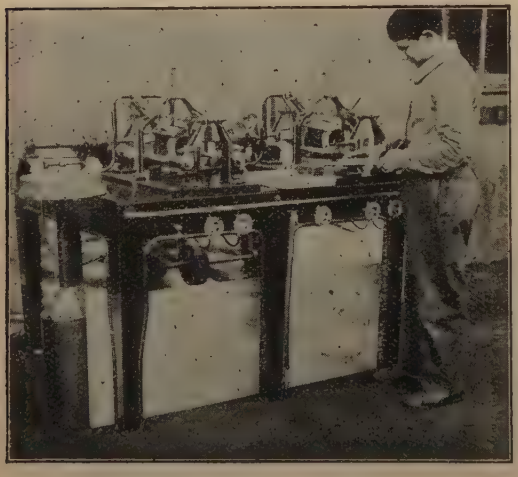


Fig. 15. — 7th phase : Trimming up slide valve face.

Fig. 16. — 8th phase : Trimming up slide valve.

3 weeks to 6 days. Certain work carried out by the belt system has enabled the following gains to be made :

— Repair of carriage bogies — gain : 30 %.

— Repair of air brake couplings — gain : 60 %.

— Repair of locomotives connecting rods — gain : 40 %.

Fig. 17. — 8th phase: Grinding slide valve on port face.

Fig. 18. — 9th phase: Complete reassembling.

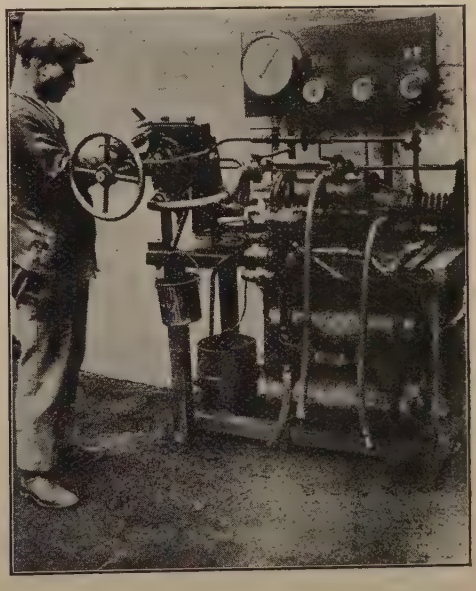


Fig. 19. — 10th phase: Testing.

The *P. L. M.* (*Algerian Lines*) have perfected similar methods in their shops.

The reorganisation of the locomotive shops of the *P. O.*, which we shall discuss at length more particularly by way of example was commenced in 1912, and

after an interruption due to the war, was re-commenced in 1919 (16).

The first step in the re-organisation (1912) was to put into force an industrial costing system to ascertain the actual cost of the various pieces of work. For this purpose, each separate piece of work was made the subject of a special order closed separately by a cost showing not only the expenses for labour and raw materials per section of the workshop but also the indirect charges relating to each of the sections of the shop. A costing system established on these principles has enabled the results obtained by improving the working methods to be measured by comparing the costs.

In 1919 a complete reform of these methods was undertaken, and was based on the replacement of the military type of control in force previously in the workshops by the functional system of management. In each main workshop, four departments have been created and these departments give orders to the workshop sections, each in regard to its own speciality :

The *fabrication department :* determination of the working methods, control of the quality of the work, fixing the time allowed;

The *distribution department :* supplying work and materials to the shops, handling, fixing the periods and controlling these periods;

The *technical department :* maintenance and improvement of the tool equipment;

The *administrative department :* questions relating to accounts, staff, correspondence, etc.

See the scheme, figure 20.

The men work on work orders issued in the workshop by the distribution department, at the moment the work is undertaken when the materials ordered has been received on the job. If necessary, these work orders are accompanied by date slips or graphs showing the dates on which delivery is to be effected.

The distribution department compiles the work and material orders, in regard to the new parts, by means of « fabrication cards » and in regard to the parts to be repaired by means of « repair cards » prepared by the fabrication department. Each of these cards provides exact information regarding the most economical method of manufacture or repair, together with the corresponding times and the necessary materials.

The locomotives are inspected periodically in the depots, and those which are to go under repair are marked six months in advance. The materials necessary for their repair are prepared so that when each locomotive enters the workshop it is certain that all these materials are in store.

This method of procedure has made the work regular and has enabled the specialisation of the staff to be carried to a high degree. Thus, in the erecting shop, the principle introduced is to cause the locomotives to move from one place of work to the other either on wheels or by means of overhead travelling cranes. Thus, each locomotive passes in succession through the hands of 7 gangs. The repair of boilers is carried out in the same way and requires 7 gangs.

The reorganisation of the shops has resulted in a considerable reduction in the time in the shops and in the cost of repairs.

The times in shops resulting from the above-described organisation are as follows :

In 1913 — average 81 calendar days.
In 1921 — average 62 calendar days.
In 1925 — average 56 calendar days.
In 1929 — average 35 calendar days.
In 1931 — average 19 calendar days.

(16) « Organisation du travail dans les grands ateliers de locomotives de la Compagnie du Chemin de fer de *Paris à Orléans* » (Organisation of work in the main locomotive shops of the *Paris-Orleans* Railway Company), Marcel Bloch, *Revue Générale des Chemins de fer*, April, May, June 1925.

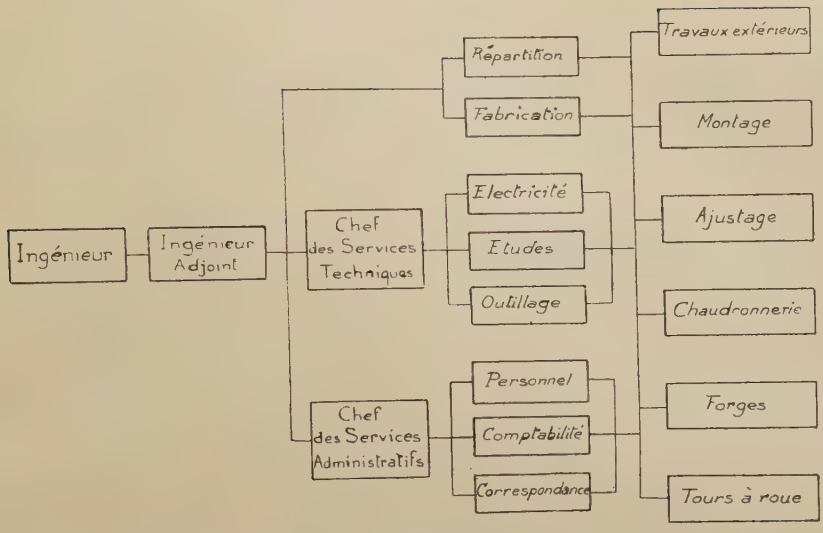


Fig. 20. — Diagram of the general organisation of a large locomotive repair shop, Paris-Orleans Railway.

Explanation of French terms:

Ingénieur = Engineer. — Ingénieur adjoint = Assistant engineer. — Chef des Services Techniques = Head of technical department. — Chef des Services Administratifs = Head of administrative department. — Répartition = Allocation. — Fabrication = Manufacture. — Electricité = Electricity. — Etudes = Designs. — Outillage = Tool equipment. — Personnel = Staff. — Comptabilité = Accountancy. — Correspondance = Correspondence. — Travaux extérieurs = Outside work. — Montage = Erection. — Ajustage = Fitting. — Chaudronnerie = Boiler shop. — Forges = Forge. — Tours à roue = Wheel lathes.

It should be noted that these reductions in the time in shops have been obtained gradually without the use of spare parts. For example, each locomotive leaves the shop with the boiler which it had when it came into the shop.

The costs have undergone similar reductions, due not merely to the re-organisation of the shops but also to the allocation of output premiums. On the whole, other things being equal, the costs have fallen by 20 %.

A film on the organisation of the work in the *P. O.* shops will be shown at the Congress.

The company's foundry has been reorganised on similar principles.

As an example, a reproduction is given in figure 21 of a plate showing the layout for white metalling wagon bearings, comprising :

— a moulding machine making moulds in circular frames.

— a mould stripping machine expelling the sand which is retained on a cast iron disc and disengages the moulding frame which may thus be used again. In this way, the mechanical equipment is made as simple as possible.

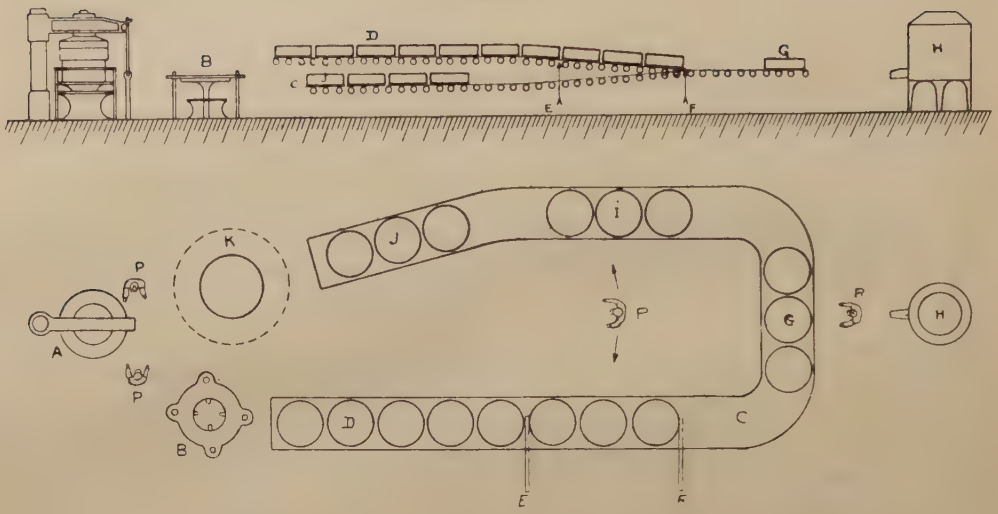
— a drum conveyor which moves the moulds by gravity between the various stations.

— a pouring station where the metal is taken from a cupola furnace. The moulds are filled three at a time.

— a screen and a separator where the moulds are tipped after the metal has cooled in order to remake the sand.

The number of men required to oper-

Fig. 21.



Detail of a mould.

Monthly production obtained from this plant : 4 000 brasses.

Fig. 21. — Lay-out of the metalling shop for wagon bearings at the Saint-Pierre-des-Corps repair shops (Paris-Orleans Company).

Explanation of French terms :

Coulée de métal blanc = Pouring white metal. — Forme en fonte = Cast iron form. — Motte en sable = Sand mould. — Disques = Discs. — Carcasse de coussinet = Body of brass.

Description :

A = Hydraulic moulding machine.
B = Hydraulic stripping machine.
C = Roller conveyor.
D = Spare moulds.
E = Stop separating 3 moulds for the pouring table.
F = Stop retaining the spare moulds.
G = Moulds in the pouring table.
H = Cupola furnace.
I = Moulds in stripping section.
J = Moulds for breaking up and recovering.
K = Sand and vibratory screen or separator.
P = Staff (4 men).

ate this station is four and the monthly output is 4 000 bearings (17).

The depot shops on this railway are organised on the same principle as the central workshops (18). However, for

(17) « Organisation du travail à la chaîne pour l'application du frein continu au matériel à marchandises » (Organisation of the belt system of working for the application of the continuous brake to goods wagons), *Revue Générale des Chemins de fer*, November 1930.

(18) « Nouvelle organisation dans les ateliers de dépôts de la Compagnie *P. O.* » (New organisation in the depot shops of the *P. O.* Co.), Pezeu, *Revue Générale des Chemins de fer*, January 1928).

all the depots of the railway, there is only one fabrication office which is dependent upon headquarters. The heavy repairs of electric locomotives of the railway are done at the workshops of Vitry-sur-Seine where the periods are six days for a general repair and four days for a limited repair (19).

Stores.

It is generally found that railways have a tendency to concentrate the district stores in as small a number of establishments as possible. They find that this gives them greater facilities for keeping a watch on their stock, and also the consumer establishments have only to deal with one store. The book-keeping is likewise concentrated in one office which may be provided with every improvement, such as card indexes, of various types, particularly the « roule class » type, calculating machines, statistical machines, etc.

Checking the stock consists in its supervision so that it will be sufficient to satisfy the demands of the consumer establishments. This supervision being based on the book-keeping results, it is necessary that the book-keeping of the stock should be in agreement with the actual state of affairs, hence the necessity for permanent control mentioned by most of the Administrations.

On the *Netherlands Railways* the control cards are brought up to date daily and the store accounts are made up by means of statistical machines.

The *North of Spain* is intending to build a single large store at Valladolid.

The *Belgian National Railway Company* has a single store at Malines for all departments. Stock is checked every week. The inventory of the articles is taken once a year and the situation of the stock is followed by means of graphs.

The *Alsace-Lorraine*, who had formerly four stores, now only possesses one. The saving in staff resulting from this concentration has been estimated at 10 %. Later on this single store will be installed in buildings to be constructed provided with improved material handling machines which will permit a fresh saving in staff of from 5 to 10 % to be effected.

The *Est* possesses four general stores in which the handling of material has been studied systematically by time measurements. The gain in time resulting is of the order of 20 to 25 %.

The *French State* has concentrated the book-keeping work of its stores in Paris in an office which has been provided with every modern appliance.

The *P. O.* in 1926 reduced the number of its stores to one. The new general store has been established at *Saint-Pierre-des-Corps*, near *Tours* (20), a locality which affords the maximum advantages not only in regard to transport between the store and the consumer establishments but also in regard to the transport between the usual suppliers and the store. It comprises a two-storey main building providing a total covered area of 18 000 m² (193 750 sq. feet) and an outside yard of 25 000 m² (269 100 sq. feet).

In order to make the best use of the covered surface the articles have been stocked in standard bins 2.80 m. (9 ft. 2 in.). high provided with benches to eliminate ladders. See figures 22 and 23 showing two views of bins of this type.

The various articles numbering about 70 000 which are kept in this store are enumerated on a list which is always kept up to date. They include articles

(19) « Ateliers de réparations électriques de la *Compagnie du Chemin de fer P. O. à Vitry (Seine)* » (Electric repair shops of the P. O. Railways Company at Vitry [Seine]), *Génie Civil*, 16 April 1927.

(20) « Note sur le magasin de Saint-Pierre-des-Corps » (The stores at Saint-Pierre-des-Corps), Gely, *Revue Générale des Chemins de fer*, June 1929.

Fig. 22. — Standard bins divided to take small mechanical details.

Fig. 23. — Gangway between standard bins divided to take woven materials.

in current supply, that is to say, articles the stock of which is kept up so that there are always parts of this category in store, the necessary articles when making alterations to the rolling stock and finally articles of rare consumption.

The order office of the general store sends out orders directly to the works of the railway and draws up the supply requisitions which are converted into orders on industry at headquarters.

The parts arriving in store are inspected in regard to quantity and quality in a special building. After this examination, the parts are distributed in the racks. The delivery of the goods is done by the issuers, on regular demands of the works, on tables where they are taken by store-keepers to be classified, packed and despatched.

The labourers make use of trucks, hoists and overhead travelling cranes for conveying the goods. They are interested in their output by the institution of the « Rowan » type of premium.

In order to reduce rejections on delivery to a minimum, orders not completed are examined by technical staff who investigate the spare parts existing in stock. This section is likewise authorised to correct immediately any errors of wording or lack of precision in these orders.

Each article has allocated to it a stock card comprising the columns necessary for entering the movements of receipts and issues and the balance. These cards are kept by means of electric automatic book-keeping machines and arranged in card (roule class) indexes (see fig. 24).

The preparation of the permanent inventory includes the checking of the receipts invoices, the calculation of the cost prices and the average prices, the discounting of issued invoices, the application of all possible additional costs and making up the day-books (suppliers and clients). All this work is carried out by electric invoicing machines with standard alphabetical keyboard. In addition, the invoices are made up by means of special large capacity machines, the documents are sorted by means of sorting machines and finally the « clients » and « suppliers » day books and also the documents for the preparation of the monthly balance sheet are kept in the form of card indexes. The introduction of these book-keeping improvements alone has resulted in a saving in staff of 56 % of the corresponding staff (see fig. 25 showing the new arrangement of the office).

In regard to the results as a whole, despite a substantial increase in the average consumption (about 20 %), the organisation of the single store described in the foregoing has enabled the original effective strength to be reduced by 26 %, while reducing the debit balance by 20 %. Finally, the direct despatch of material to the using works results in a definite saving in transport and also reduces the time taken.

Permanent way department.

Organisation of the technical offices.

In their main features, these offices are organised like those of the other two principal departments (operating, rolling stock and locomotive running) which have been described previously. Each of them specialises in part of the questions arising in its department. By way of example, we shall describe in the following the organisation of the steel constructions designing office of the *Est* Railway.

This office is under the management of an engineer and includes calculators and draughtsmen. Based on the general data supplied by the local staff, the calculators effect the calculations of the strength by means of electrical or hand calculating machines. According to the data of these calculations, the draughtsmen make the drawings of the entire work and its details. These draughtsmen controlled by a chief or assistant

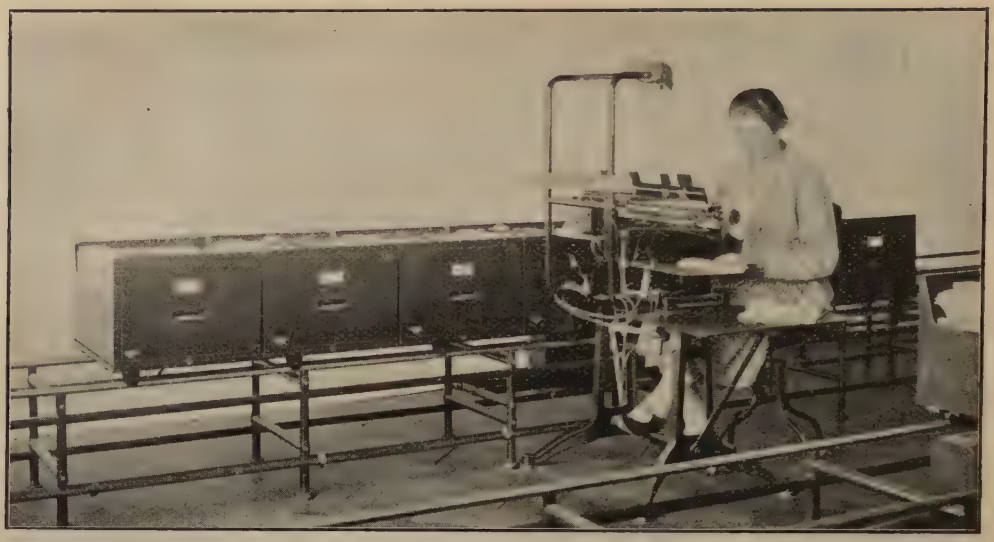


Fig. 24. — Rolling filing cabinets used at the Saint-Pierre-des-Corps stores.

Fig. 25. — View of the new office of the Saint-Pierre-des-Corps stores.

chief draughtsman are generally grouped by threes : a head draughtsman, a draughtsman and a tracer.

In principle, none of the calculators or draughtsmen specialises entirely in steel or in reinforced concrete construction, but when the work is distributed, the greater or lesser aptitude of each of them for the investigation of one of these materials is taken into consideration. Finally, before being submitted to the chief engineer for approval, the drawings are checked by a chief draughtsman and gone over by the calculator who prepared the scheme.

The *Nord* mentions that in one drawing office is has made a trial of the organisation of the work based on the use of wall diagrams provided with coloured markers, similar to those of the drawing offices of the rolling stock and locomotive running department (*P. O. Railway*) described in the foregoing.

Inspection and maintenance of tracks. Permanent way works and buildings. Tracks.

The replies which we have received show that the railways have the tracks inspected daily by platelayers, watchmen, etc., and that other inspections at longer intervals are made by the supervising staff.

Apart from these inspections, the tracks are checked periodically by means of recording apparatus or by means of the « Hallade » oscillograph. By studying the graphs made by this instrument, it is possible to follow up systematically the state of the tracks.

The *P. O.* mentions that they have improved an apparatus for recording while running, and of course under load, any difference in level of one rail relatively to the other.

As regards maintenance, almost all railways tend to employ the method of general overhaul, such that a portion of the track is entirely overhauled periodically, the track not taken in hand being given such attention as will ensure that it will remain in a satisfactory condition until the general overhaul.

The work out on the track may also be carried out in accordance with a programme such that all the operations (weeding, stripping, repair of fastenings, etc.) follow one another in a continuous sequence like the work in the shops. In addition, the *L. M. S. R.*, the *L. N. E. R.*, the French *Nord, State* and *P. O.* and the *Netherlands* railways report the extensive use of mechanical means (self-discharging ballast wagons, weeding units, etc.). Finally, the *Nord, Est, State* and *P. O.* Railways level up the track by means of mechanical tamping and controlled shovel packing up of the sleepers. The *P. O.* adds that the maintenance gangs are moved from place to place either on trolleys or by bicycle on paths specially made alongside the track for the purpose, so as to increase the effective working hours of these gangs.

By way of example, we shall describe the work of relaying the track as carried out on the *Nord* (21).

The method employed is as follows : The ballast down to the formation level is removed and cleaned by means of mechanical appliances : Drouard combined stripping and screening machine or Scheuchzer stripping machine. In addition, the track is taken up and laid by entire lengths by means of Drouard motor driven crane wagons running on the adjacent track, or Loiseau-Collet gantry cranes running on a special track the rails of which are laid outside the track which is to be re-laid (in this last method, the lengths of track which have been taken up or the new lengths are transported between the adjacent stations and the working place on special wheels and axles running on the ordinary track).

(21) *Revue Générale des Chemins de fer*, October 1929 and March 1931.

In addition, the new tracks are assembled by mass production at the *Moulin-Neuf* shops, and the same applies when dismounting the old tracks. This work is facilitated by the use of electric coach screw driving machines, a 10-ton gantry crane with a 12-m. (39 ft. 4 1/2 in.) span for loading and unloading the batches of rails and of the complete lengths of track and two light gantry cranes for carrying the loose rails and putting them into position. The additional ballast is conveyed by special trains composed of side hopper wagons for rapid unloading continuously alongside (the outside and in the middle of) the relaid track. The new track is rapidly lined up by means of Collet electric tampers. This method of track relaying is the subject of a film which will be shown at the Congress.

Finally, we would remind the reader that the « Recent improvements in permanent way tools and in the scientific organisation of maintenance work » formed the subject of reports presented at the Madrid Session (Question IV), and that « The use of mechanical appliances in the permanent way maintenance and track relaying » forms part of the programme of the Cairo Session (Question II).

Permanent way works (bridges, etc.).

The permanent way structures are inspected in the same way as the tracks. On most railways, however, the result of the examination is entered into a special register in which are collected the principal points to be examined.

Moreover, on the *French Railways*, detailed inspections are made every five years.

From the point of view of maintenance, the *Est* has mentioned the formation of four gangs of steel erectors selected by competition. These gangs have to carry out the less important repairs to the structures. As a rule, one gang undertakes the repair of all works on one line and carries it through to the end. In addition to this repair work, the gangs have to assemble and put in position the temporary bridges frequently employed for certain work such as : large repairs, the construction or replacement of works, etc. A tool equipment wagon accompanies each gang.

Buildings.

The railways indicate periodical and systematical inspections of certain parts (roofs, sliding doors, trainmen's rooms, etc.).

The *French State* mentions that the maintenance of buildings is carried out as far as possible at the same time as the important line repairs so as to concentrate the efforts in a definite field, this resulting in increased order, more efficient control and an easier organisation of the work.

Organisation of the work in the shops.

The permanent way department workshops are often of little importance, since generally railways obtain their fixed plant from the trade. However, those railways who form an exception to the rule and possess workshops of some size have made use of the methods previously described in the paragraph relating to the principal workshops of the rolling stock and locomotive running department. We shall mention more particularly the *Nord* who a year ago put into service a rational organisation of the work in the rail machining shop.

The preparation of the work forms the subject of orders, construction cards, work dockets, etc. In addition, the distribution of the work is effected with the aid of a distribution table, which permits the work to be distributed and followed up rationally by means of card slips, the lengths of which are proportional to the pre-determined machining times. This table also shows the work to be done by the machines and shops. In addition, work progress table, supple-

Fig. 26. — Table showing distribution of work.

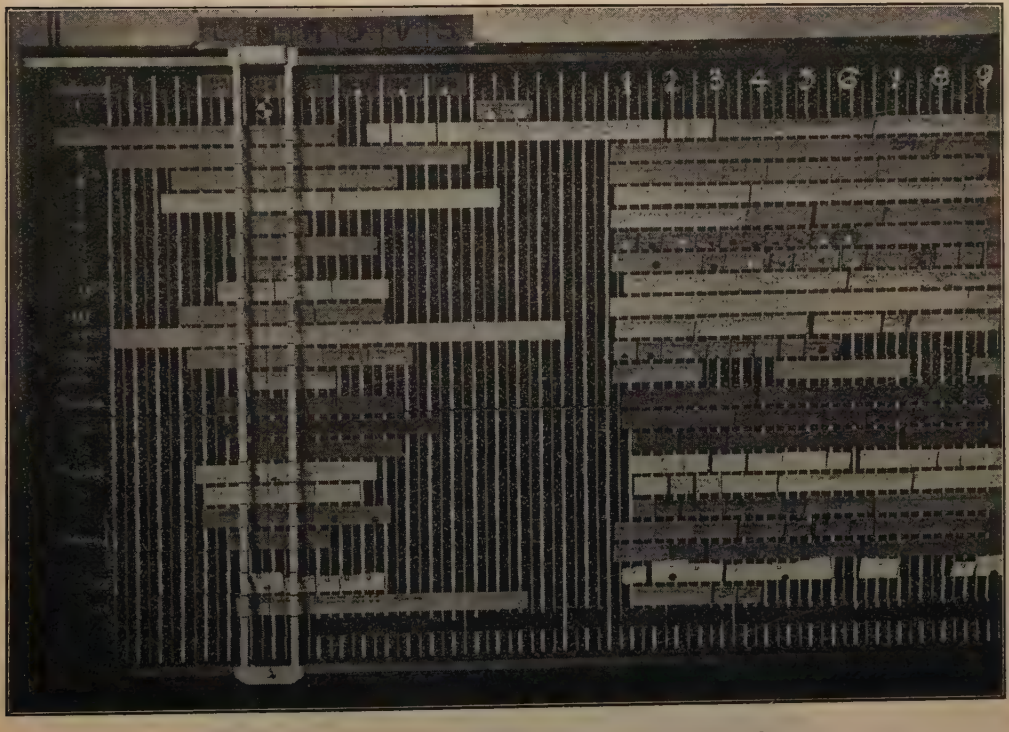


Fig. 27. — Table of work of the machines and the shops.

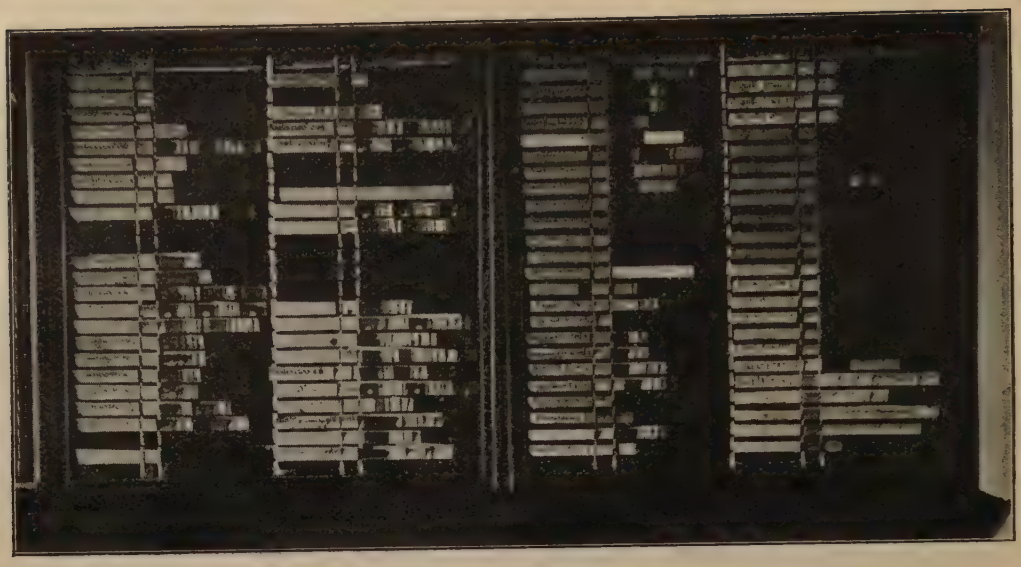


Fig. 28. — Table showing progress of orders.

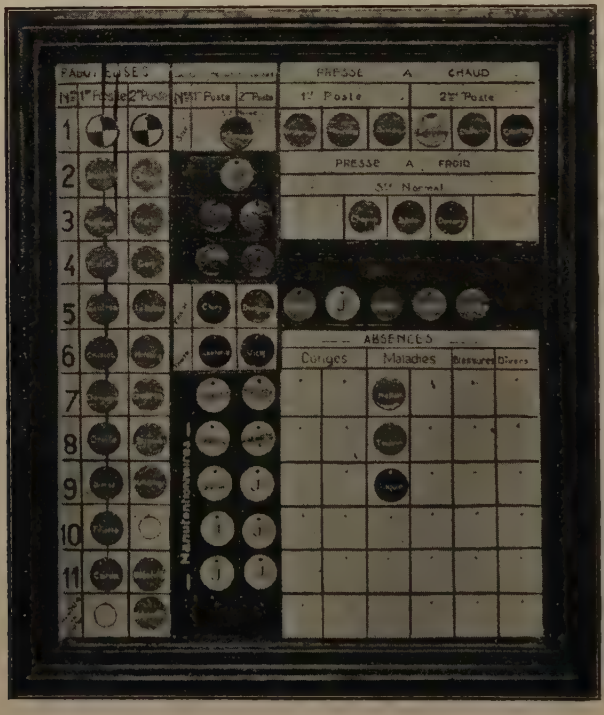


Fig. 29. — Table showing distribution of labour.

mentary to the distribution table, permits the state of progress of a definite piece of work to be followed up, on this table, by means of slip representing the operations, the slips being re-grouped as the operations are completed. Finally, a labour distribution table — on which each workman is represented by a marker of a different colour differing according to the shop and on which each machine is represented by a square — facilitates the methodical and rational distribution of the labour in terms of the effective number of men present and the magnitude of the work to be done.

Operation times have been set and a system of individual premiums has been instituted. In order to perfect this organisation, improvements in regard to details have been made in order to relieve the workmen of all work of a secondary character. Thus, the sharpening of all the tools is entrusted to a specialised tool man and the handling of materials is done by labourers.

The *Nord Railway* adds that the applications of these various measures has improved the general efficiency by 30 to 35 % and has increased the premiums received by the workmen in the proportion of 15 to 35 %. Reproductions of the tables referred to above are given in figures 26 to 29.

In its workshops at La Garenne, the *State* has likewise improved the working methods and has put into practice the most up-to-date mechanical means. We would add that these shops carry out the construction of track apparatus and various kinds of apparatus for fixed plant and for signalling, the manufacture of forged parts and spare parts, the machining and assembling of parts supplied in the rough, assembling of interlocking plant, finally the testing and examination of rails, broken or damaged in use, etc. The scheme of the organisation for carrying out orders in these shops is shown in figure 30.

Stores.

As in the case of the large stores of the rolling stock and locomotive running department, we find a tendency to concentrate the stocks in a small number of yards or stores, the local sections merely keeping the material which is strictly necessary for meeting urgent cases.

The advantages which railways gain from this concentration have already been dealt with in connection with the stores of the rolling stock and locomotive running department.

The *Nord* in particular states that, at the stores au *Moulin-Neuf*, the 30 000 store cards are kept (partly by hand and partly by machine) by one employee only by means of a special filing device served by a « Roule-class » filing system.

CHAPTER III.

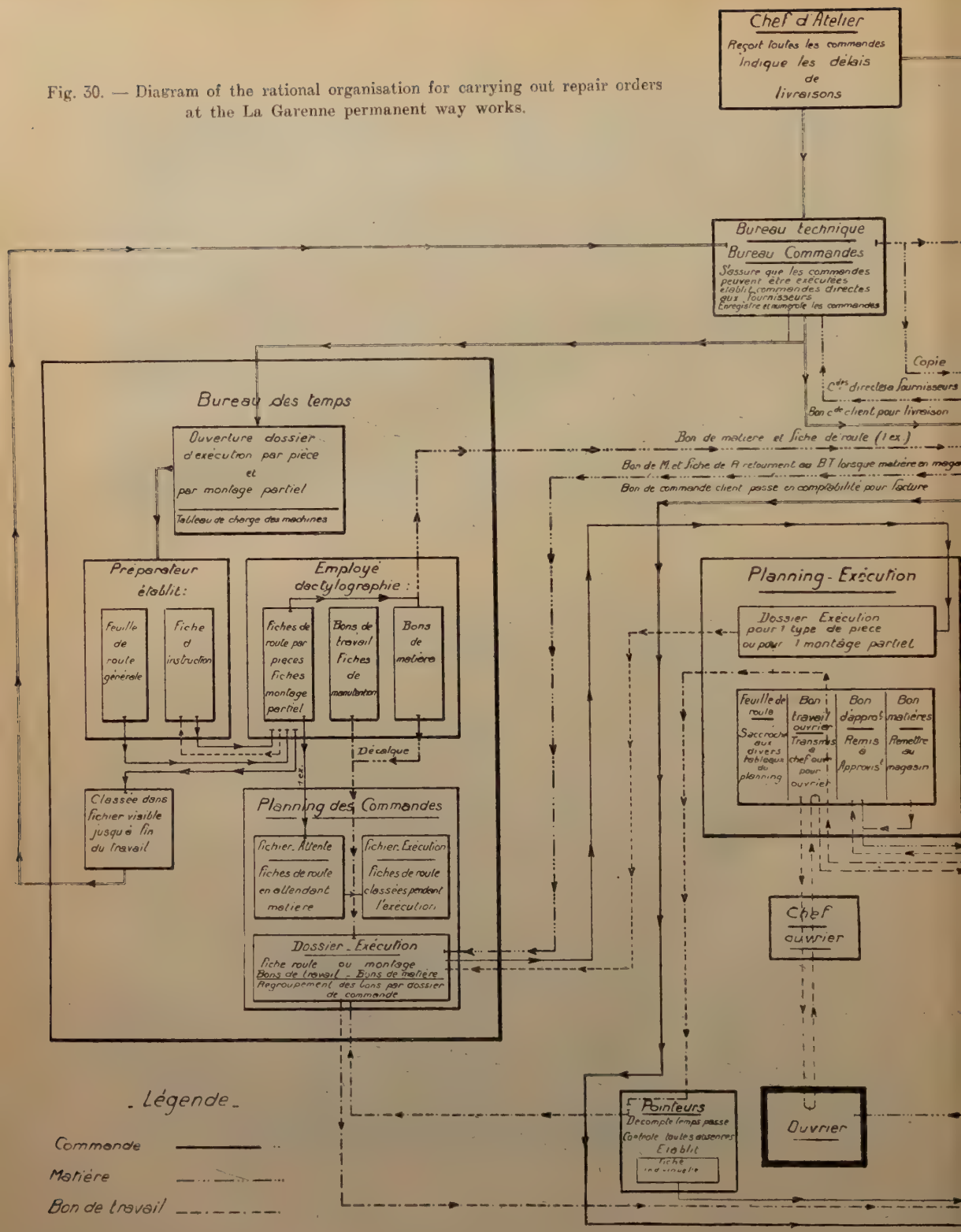
Improvements effected by standardising the dimensions and the qualities of the materials of detail parts and units employed by railways.

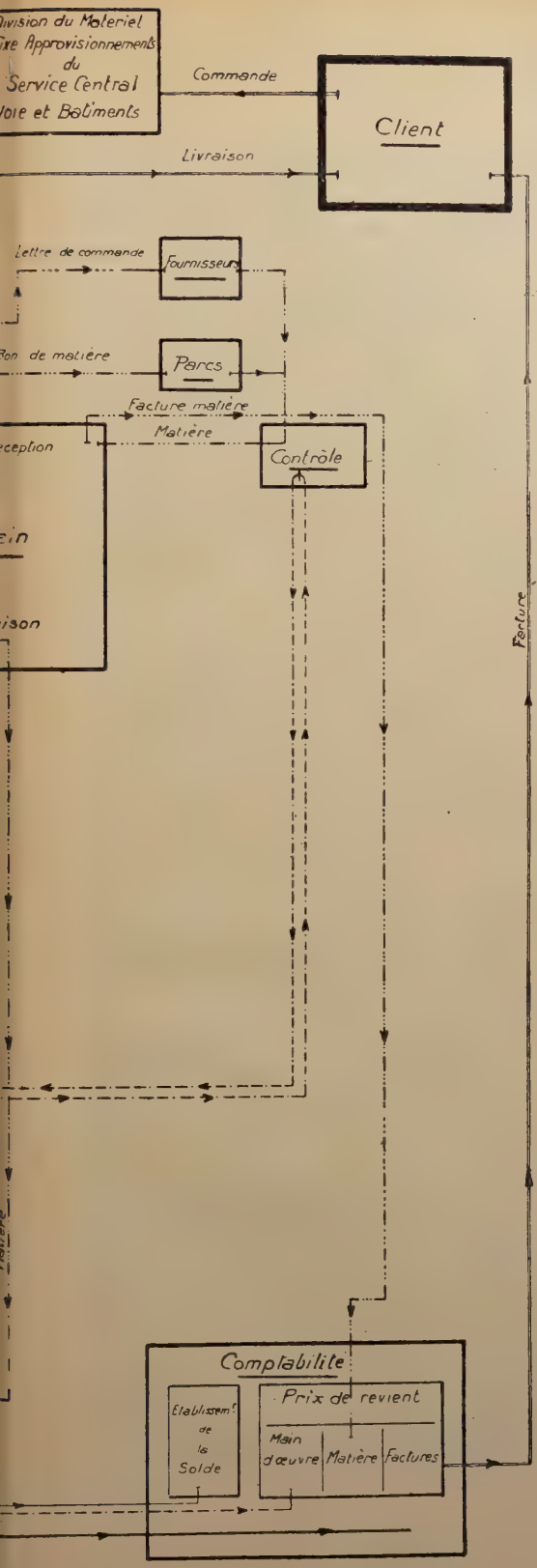
Standardisation.

The standardisation of materials, of the dimensions of detail parts or of their qualities, as well as that of the units built up of parts used by an undertaking is closely bound up with the rational organisation of this latter.

In fact the advantages to be derived from standardisation independently of the reduction in the amount of stocks in store, are the reduction in the cost of the materials, due to the fact that a larger number of parts is ordered each time, and the possibility for the undertaking to organise its operations rationally by the choice of parts or units of standard parts likely to give the best guarantees whether from the point of view of purchase or from that of repairs.

Fig. 30. — Diagram of the rational organisation for carrying out repair orders at the La Garenne permanent way works.





Top and right hand side: Chef d'atelier: Reçoit toutes les commandes. Indique les délais de livraisons = Shop foreman. Receives all orders. States delivery date. — Division du matériel fixe. Approvisionnement du Service central, voie et bâtiments = Fixed appliances department. Supplies for the headquarters of the permanent way and works department. — Commande = Order. — Livraison = Delivery. — Client = Customer. — Lettre de commande = Written order. — Fournisseurs = Suppliers. — Bureau technique. Bureau commandes: — S'assure que les commandes peuvent être exécutées, établit commandes directes aux fournisseurs. Enregistre et numérote les commandes = Technical office. Order office: Makes sure orders can be filled; makes out orders direct on suppliers. Registers and numbers the orders. — Bon de matière = Material ticket. — Parcs = Stockage. — Facture matière = Material invoice. — Matière = Material. — Réception = Reception. — Contrôle = Check. — Comptabilité = Accountancy. — Etablissement de la solde = Getting out wages. — Prix de revient: Main-d'œuvre. Matière. Facture = Cost price: Labour, Material, Invoices. — Magasin = Store. — Livraison = Delivery.

Left hand side: Bureau des temps = Time office. — Ouverture dossier d'exécution par pièce et par montage partiel = Starting file re-carrying out work by detail and by part erection. — Tableau de charge des machines = Table of work at the machines. — Préparateur établit: Feuille de route générale; Fiche d'instruction = Employee on preparatory work gets out; General route card. Instruction card. — Employé dactylographie: Fiches de montage partiel. Bons de travail; Fiches de manutention; Bons de matière = Typist gets out: Route cards by parts; Part erection cards. Work orders. Handling cards. Stores cards. — Décalque = Trace. — Classée dans fichier visible jusqu'à fin du travail = Classified in visible card index until end of work. — Planning des commandes = Planning the orders. — Fichier. Attente. Fiches de route en attendant matière = Card index. Waiting route cards whilst waiting for material. — Fichier. Exécution. Fiches de routes classées pendant l'exécution = Card index. Making out route cards held in index during the carrying out of the order. — Dossier. Exécution: Fiche route ou montage. Bons de travail. Bons de matière. Regroupement des bons par dossier de commande = File. Exécution: Making out route card or erection card. Work orders. Material orders. Resorting according to order files. — Légende. Commande. Matière. Bon de travail = Explanation. Order. Material. Work order.

Middle: Copie = Copy. — Commandes directes fournisseurs = Direct orders on suppliers. — Bon commande client pour livraison = Customer's order for delivery. — Bon de matière et fiche de route (1 ex.) = Store order and routing card (1 copy). — Bon de M. et fiche de R. retournent au B. T. lorsque matière en magasin = Stores ticket and receipt card returning to technical office when materials in store. — Bon de commande client passe en comptabilité pour facture = Client's order passes to accounts for invoice. — Planning. Exécution = Planning. Execution. — Dossier. Exécution pour type de pièce ou pour montage partiel = File. Execution for type of part or part erection. — Feuille de route. S'accroche aux divers tableaux du planning = Waybill. Attached to the different planning tables. — Bon travail ouvrier. Transmis à chef ouvrier pour ouvrier = Work order to workman. Handed to charge hand for workman. — Bon d'approvt. Remis à approvist = Supply order. Sent to stores. — Bons matières. Remettre au magasin = Material orders. Handed to the stores. — Chef ouvrier = Charge hand. — Pointeurs. Décompte temps passé. Contrôle toutes absences = Timekeepers. Reckon time taken. Check all absences. — Fiche individuelle = Individual cards. — Ouvrier = Workman.

Standardisation of dimensions.

The standardisation of the parts of machines or tools is undertaken in every country by national committees whose work at the present time is in a more or less advanced stage. The national standards are afterwards examined by international organisations with a view to deriving therefrom standards applicable in all countries.

In their reply, the *French Railways* have shown the part they have played in the investigation of the French standards. It may be presumed that, in view of the importance of the undertaking they represent, the railways of the other countries have played a part just as important in regard to their own national standardisation committees.

The questions set by the reporters to the various administrations did not merely concern their adoption of national or international standards, the advantage of which would appear to be indisputable, but more particularly the application as extensively as possible of the idea of standardising the whole of the railway material.

Connected with the standardisation of new parts is the standardisation of reconditioned worn parts. It is possible in numerous cases to bring the repaired part back to the original dimensions when, in order to ensure interchangeability of new and repaired parts, it is merely necessary to adopt the same machining tolerances for both.

Some parts cannot be brought after repair to the original dimensions. In cases of this sort, it will be necessary to adopt a method consisting in standardising the dimensions of repaired parts and also of the adjacent parts, so as to ensure in every case interchangeability without additional adjustments while making use directly of the spares existing in store.

When it is employed, this method affects parts such as locomotive cylinders and piston rods, journals of axles and bearings, pins and bushes, etc. Only a few examples of the use of this method of repair have been given by the administrations consulted.

Locomotives and rolling stock.

Judging by the replies which we have received, railways have been interested for some years in the standardisation of locomotive, carriage and wagon parts.

The application of this idea resulted in the first place in reducing to a minimum the number of types of locomotives or vehicles. In addition, with the exception of those parts which necessarily differ from one type to another, newly constructed stock always contains parts uniform with the best type of those in use.

The use of this standard type is likewise generalised on old stock according to the case either regularly or on certain occasions according to circumstances.

The *British* Railways have followed this policy for a number of years, particularly the railways of the home country who received a large number of types of locomotives from the constituent companies. For example, the *L. M. S. R.* which in 1922 had no less than 300 types of locomotives had reduced this figure to only 129 in 1928. The *Eastern Bengal* Railway has carried out systematically the standardisation of locomotive parts. The *South African* Railways have taken steps to reduce the number of boilers mounted on their locomotives. This number has thus been reduced from 13 to 2.

The *Netherlands* Railways have likewise made efforts to reduce the number of parts. They have furnished a list of 50 types of locomotive parts, the number of which through standardisation has been reduced from 642 to 218.

The *North of Spain* and the *Andalusian* Railways state that new types of carriages and wagons were standardised for all the *Spanish* Railways in 1925 as a result of governmental action.

In 1918, the *French Railways* instituted the « Central Railway Rolling Stock Resarch Office » (Office Central d'Etudes de Matériel de Chemins de fer) which on request prepares designs of standard rolling stock and has obtained interesting results in regard to standardisation.

Permanent way material.

Standardisation of permanent way material is particularly complete on the various railways of any one country in regard to everything concerning the rails or the sleepers.

The Railways of the *British Empire* have made very considerable progress in regard to the standardisation of their fixed material. The *Eastern Bengal* Railway and the *Madras and Southern Mahratta* Railway only construct standardised buildings.

The *Dutch East Indies* Railway Co. do the same except as regards the main stations and the administrative buildings.

The *Netherlands* Railways have carried out the complete standardisation of their manual and electrical signals.

As regards the *French Railways*, the *Alsace-Lorraine*, the *Nord* and the *P. L. M.* mention the use of standardised types of buildings and some of their constituent parts.

The *Nord* Railway has carried out experiments on the standardisation of permanent works : as a whole and in detail.

The *Est* Railway has standardised signals as well as types of stations which now number 5.

The *State* has adopted a certain number of types for the outbuildings of level crossing keepers' houses and stations. They have also standardised some of the signalling plant (track relays, telephone material, etc.).

Office material. — Printed matter.

All the railways are interested in the reduction of types of sizes of paper, which results in a reduction in the number of holders. This question is in abeyance pending the international standardisation of paper sizes which has not yet been settled.

The office material is the subject of similar investigations.

Tools.

The standardisation of the tools employed is mentioned by those of the railways who have investigated the rational organisation of their shops. The practical results obtained by this standardisation are embodied in those which have been mentioned as a whole as the consequence of the application of rational organisation to the railway workshops.

Standardisation of quality.

The standardisation of quality consists in fixing a number as small as possible of types of materials intended to be used for the different parts and beginning by determining the tests to which these materials have to be subjected in order to ascertain that they are really true to type.

The *French* Railways have been engaged on the standardisation of quality for about thirty years and have jointly established a complete collection of technical specifications and conditions to be observed by suppliers. The standardised specifications and conditions for supply cover all categories of supplies that is to say, both metal and wood, paints, etc.). They concern both raw materials and finished materials, assembled parts such as brake fittings and finally complete vehicles.

SECOND PART.

Methods of interesting the staff in the railways.

General considerations.

In the first part of this report, we showed the importance of the rational

organisation of work in improving the efficiency of railways and ensuring their operation under good conditions of security and regularity.

As we pointed out in the introduction, this question of organisation is only one of the factors in the satisfactory operation of the railways. If they are to be able to fulfil their social duty and to direct this organisation, assumed to be the most perfect possible, it is indispensable that they should have an instructed staff, devoted and interested in the improvement of the results obtained by the railway.

The principal steps which the railways have been induced to take in this province are as follows :

— the general conditions of remuneration of the staff.

— the necessity which there may be in some countries of varying this remuneration in accordance with family expenses and housing and hygienic conditions.

— the interest there may be in apportioning the remuneration according to the quality and quantity of the work performed.

— the security assured to the staff in regard to the future and old age.

— improvement of the health of the staff and its working conditions.

— social work, that is to say, steps whereby the railway uses its influence to make the private life of the employee and his family more comfortable.

— the collaboration of the staff in the operation of the railways.

— improvement in the professional training of the employees.

— the participation of the staff in the general results of the undertaking.

CHAPTER I.

General conditions of remuneration.

1. *The remuneration as a whole.*

The remuneration is instituted either in a one-sided manner by the employer only, the social and economic conditions of the country being taken into account, or with the more or less direct co-operation of the employees who may afterwards demand an agreement stating precisely the wages conditions which as a rule are fixed at determined rates.

The first form was universally employed until recent years. Now it is the exception only.

Thus the *Spanish* railways, the *North of Spain* in particular, remark that although there is no staff agreement, they apply to the conditions of remuneration rules which are published in the general instructions of the company, the management orders and circulars and which the railway has decided to observe towards its employees.

The *Belgian National* Railway Company has defined the conditions of remuneration of its staff by a general order which will be incorporated in the staff agreement now in preparation. The conditions are very similar to those in force in France.

The *Sudan Government* Railways, apply to their staff the pay regulations in force for Government servants.

The same applies for the *Federated Malay States* Railways whose employees are paid at rates fixed by the tables authorised by the Government.

The second method is now the most generally employed by the Administrations who have sent in replies. It has been used on the *French* Railways since 1920, at which time, after arbitration, a staff agreement settled the rates of pay as well as the conditions of increase and the methods of promotion. The feature of this agreement is that of the application to each definite function of scales of pay, each comprising a series of successive grades through which the employee passes according to seniority, the seniority required for passing from one grade to another being altered according to the quality of the service rendered.

The *British* Railways, although they

have no agreement, employ a system which is quite similar and which also comprises scales of pay. The rates of pay are fixed in agreement with the organisations representing the employees affected, that is to say, the Railway Trade Unions, or through the Industrial Court and National Board and even through the National Maritime Board when the matter concerns employees in the maritime services of the Railways.

On the *Canadian National* Railways, the level of the wages has likewise been fixed by negotiations between the railway and the representatives of the employees' groups. The successive adjustments have resulted in arrangements similar to the rules followed in the United States since 1919. Any disputes which may arise in the matter of the wages of the staff or the regulation of the work are settled by arbitration or by law before tribunals provided expressly therefor.

On the *New South Wales Government* Railways, the wages are fixed by an arbitration tribunal comprising representatives of the organised groups of the staff. The methods of promotion are fixed under the same conditions by a section of the « Government Railway Act », that is to say of the staff agreement.

The *Portuguese* Railways have adopted a staff agreement, as also have the *Netherlands* Railways (for both the home country and the Indies), the *P. L. M.* (*Algerian Lines*), etc.

The *Ceylon Government* Railway does not possess any staff agreement but has fixed scales of pay.

The *South African* Railways employ scales fixed in accordance with the cost of living and the pay of staff in other industries. These scales are fixed in agreement with the Trade Unions or the representatives of the staff. A seniority bonus of 1 shilling a day is granted to all employees with more than 20 years of service.

Among the replies which have been sent in to us, mention ought to be made of two particular cases in which the pay of the staff is fixed only in so far as regards the basic rate, its real rate of application being dependent upon a coefficient which varies with the general economic conditions of the country in question :

The *Nord Belge* Railway where the pay of the staff varies in accordance with the coefficient of increase applied to the 1922 goods rates.

The *Guillaume-Luxembourg* Railway on which the pay of the staff varies according to the cost of living index fixed by the Statistics Department of the Grand Duchy of Luxemburg.

2. *Housing and family allowances.*

We have previously emphasised the interest there may be in certain cases in providing special allowances with a view to adjusting the particular needs imposed either by the employee's residence or his family expenses. The adjustment of the wages according to the duties of the employee and to his seniority do not always permit this object to be attained, particularly in countries where there are considerable differences in the necessary living expenses according to the regions or localities.

Most of the railway administrations who have sent in replies have therefore solved the question by granting allowances to take these two conditions into consideration. It is the system which has gradually evolved itself from the successive economic difficulties that Europe has known for 20 years.

It is in particular the system adopted by the *French* Railways who grant housing allowances, varying according to the locality, and family allowances which also vary according to the number of dependent children, for every child less than 18 years old dependent upon the employee. The rate of these allowances increases with the number of children.

Very similar methods are applied in *Belgium*.

The *British* Railways grant housing allowances for the whole of their salaried staff residing in London or its suburbs, and also in the large industrial areas. In regard to the workshop staff, the towns are classified into 5 categories with different rates of pay. In this country, however, the necessity for family allowances has not made itself felt.

The Railways of *Spain, Portugal,* etc., grant housing allowances and family allowances like the *French* Railways.

The *Netherlands* Railways attain the same results in a slightly different form. The communes are distributed into 4 classes and to each class there corresponds a rate and a special scale of wages which take into account the difficulties and cost of living. They also grant family allowances.

Housing and family allowances are extensively developed by railways operating in tropical countries. The climatic conditions necessitate very special and very expensive material conditions for the European staff.

In certain cases even, a part of the pay is represented by the provision of foodstuffs, housing accommodation or the necessities of life. This is the case of the native staff who have to assure the railway service across regions without any resources of their own, as for example in Africa.

As a particular case to be noted, the *South African* Railways have instituted a special allowance for their employees engaged in certain districts where they are obliged to take special hygienic measures to protect themselves from malaria.

3. *Efficiency premiums and bonuses.*

The question of the premiums which some railways have considered necessary to grant to their staff as a reward for the quality and quantity of work, and also the economies resulting therefrom by an improvement in the efficiency has been dealt with in the reports presented on Question XV at the 1930 Session of our Association.

We do not therefore intend to return to that which was stated in regard to the countries we dealt with at the Madrid Congress and shall refer our readers to the 1930 reports.

However, the railway administrations who have sent in replies to our questionnaire for the 1933 Congress in some cases have pointed out that they have developed the steps which were taken in this connection before 1930 and other railways, for which we were not the reporters in 1930 have been good enough to explain what they have done in this connection.

The *Alsace-Lorraine* Railways in 1931 instituted an efficiency premium for the shunting staff of the operating department. These premiums are calculated according to the value of the work actually carried out by the station in the period considered for fixing the premium as compared with the maximum work which may be required from this station according to a typical table of arrivals, shunting of trains and departures of trains. In this manner a first element is obtained for the evaluation of the premium which may be allowed if the hourly performance of the day in question is greater than the average hourly performances of the preceding year and of the current year up to the day in question. On the other hand, these premiums are subject to individual or collective stoppages which are made for mistakes committed in carrying out the work, damage to rolling stock, delays, etc. Taken as a whole, these efficiency premiums may increase the fixed wage of the employees in the proportion of 6 to 8 %. These premiums are granted to the locomotive men driving the shunting locomotives.

The *Alsace-Lorraine* Railways also announce that it is their intention to

extend again on a large scale the system of efficiency premiums which they apply to their staff.

The *Nord* Railway quite recently decided to grant to workmen and labourers of the rolling stock and locomotive running department efficiency bonuses based on the saving in time effected on the work done or on the time allowed for the different pieces of work.

The foremen and assistant-foremen likewise receive a bonus calculated in proportion to the efficiency of their gang.

In the depots, the foremen and assistant-foremen receive in addition a supplementary premium in proportion to the number of locomotives repaired and the mileage run by the depot locomotives without repair.

The *Paris-Orleans* Ry. has just granted an output premium to the typists at headquarters. This premium is proportional to the total number of days of work done in the month by all the typists in relation to the number of working days. A bonus is also granted taging into account the individual quality of the work, but a new formula is under consideration.

The employees of the mechanised office receive a premium proportional to their output which may attain a very high rate, since the best operators thus receive as premium 20 % or their fixed wage. The same formula has been extended to the operators in the slow traffic and fast traffic offices of the *Paris* stations.

The system of premiums applied in 1930 to the employees of the rolling stock and locomotive running department has been improved in several details in order to adapt the magnitude of these premiums better to the quality and quantity of the work done.

The *French State* Rys. have extended the system of premiums to the employees of the operating and of the locomotive running departments, whose task it is to make out the wages of the staff. In addition, the staff of the workshops and permanent way department now receive premiums under the same conditions as those granted previously to the staff of the locomotive running department.

The *P. L. M.* Ry. informs us that in 1930 the premiums granted to the staff of the rolling stock and locomotive running department resulted in an average increase in pay of

44 % for the drivers,
38.5 % for the passed firemen,
36.5 % for the drivers on probation,
22.5 % for the shunting drivers,
22 % for the workshops staff,
16.3 % for the firemen.

The *Belgian National* Railway Company is considering a new and interesting premium formula which it is believed, will be capable of improving the goods train service. This new system is based on the following factors which have been deduced as being characteristic of good efficiency: 1. Number of wagons shunted per hour by the shunting locomotives; 2. Number of wagons shunted per man; 3. Satisfactory utilisation of the power of the goods locomotives; 4. Regularity in despatching trains. All employees cooperating directly in the service participate in the premiums. On the other hand, penalties will reduce the premium individually or collectively as a punishment for making mistakes.

The *Belgian National* Railways likewise inform us that they are going to extend the efficiency premiums to all the permanent way services.

In short, the question of premiums continues to be developed on the lines indicated in our 1930 report ([22]). The railways who employ this system are extremely numerous and in replying to our

([22]) See *Bulletin of the Railway Congress*, November 1929, p. 2533.

questionnaire have stated that they are continuing to follow up the question on the lines indicated at the Madrid Congress. Efficiency premiums are mentioned as having given very interesting results in certain cases.

For example, these premiums enable the staff of the machine shops of the *South African* Rys. to increase their normal standard rate of pay by 25 %.

The *New South Wales Governement* Rys. provide their shop employees with the option of choosing between the standard pay and a special pay based on output, and which provides for the grant to the staff of the value of 50 % of the time gained when working properly. In this way, very good workmen can increase their pay, but the less skilful workmen are always certain of receiving the standard wage not being paid by results.

4. *Conditions of promotion of the staff.*

These conditions are determined by the staff agreement on those railways which have one. The rules of promotion take into consideration merit and seniority, but it must be admitted that seniority alone can never enable an employee to attain a post which he is incapable of filling. Reports, examinations, competitions, etc., enable the necessary selection to be made.

The staff agreements of the *French* Railways enable the employees to see that the promotions have been regular by the publication of qualification reports and tables on which the employees who have to be considered for promotion are entered in the order to be observed for the nominations.

The same applies to the *Guillaume-Luxembourg* Railway, the *Belgian National* Railways, etc.

On the *Portuguese* Railways, the employees of the active service have to pass an examination before each scale promotion and the promotions are distributed in two parts: one part is made by merit, and the other by seniority.

The *Spanish* Railways have no staff agreement, the conditions for promotion being provided by their own domestic regulations.

On certain railways of *Asia* and *Africa*, the conditions for promotion are quite special in view of the nature of the staff which includes Europeans and native employees. However, on a certain number of these railways, for example the *Dutch East Indies*, the *Franco-Ethiopian* Railways, etc., a staff agreement has been passed which, in addition to the conditions of pay, also defines the conditions of promotion.

The *Eastern Bengal* Railway and the *Ceylon Government* Railway have a system similar to that of the *Spanish* Railways; the conditions of promotion form the subject of each Company's own regulations.

The *South African Railways*, the *Sudan Government Railways* and the *Federated Malay States* Railways apply conditions of promotion which are officially approved by their Government and which in certain cases involve, in addition to the selection of the employee, success in passing an examination for promotion to the higher grade.

5. *Discipline.*

In addition to the arrangements made for the reward and promotion of deserving employees, the railways are obliged to introduce disciplinary measures for dealing with cases of infringement of regulations. These measures, moreover, are also often taken in the interest of the staff themselves who, for reasons of vital importance affecting their own safety, ought to obey the regulations and apply them in every circumstance.

On railways where there is a staff agreement, such as the *French* Railways, disciplinary measures are provided by

this agreement. They are of various degrees and, according to their seriousness, they are administered by the head of the district or division, the departmental head or the general manager.

Serious punishments to be imposed by the general manager are first put forward as a proposal upon which a board of enquiry composed of equal numbers of delegates of the management and of the staff has to give an opinion.

This board of enquiry acts as an actual advisory tribunal and the opinions it gives are final in character as regards the maximum punishment to be inflicted, that is to say, the general manager may confirm the decision of the board of enquiry or may administer a lighter penalty, but he cannot increase the punishments which are recommended to him, unless these punishments have not been agreed to unanimously and provided the Minister of Public Works is notified.

The *Belgian National Railway Company,* although it does not possess a staff agreement, acts in the same way. This Company has passed a general order constituting a real administrative penal code. As in France, the penalties are applied according to their seriousness by the immediate chief, the departmental head or the general manager and for the most serious punishments, there is a « council of appeal » composed of a stipendiary magistrate, a recorder and 10 assessors, half of whom are selected by the *National Company* and half are elected by the staff.

The *Netherlands* Railways have instituted an arbitration tribunal having the power to decide without appeal the penalties to be imposed. This tribunal is composed of 3 members, one of whom represents the staff.

The *North of Spain* allow their employees who have received a punishment to lay an appeal before the arbitration tribunals instituted by the Government.

The *British* Railways, when dealing with punishments, have instituted the procedure which provides for the intervention of the railway trade unions. The *Railways* in the Dominions observe similar rules whereby the staff representatives are made aware that punishments have been applied.

The *Guillaume-Luxembourg,* when applying disciplinary measures, has provided arrangements similar to those used in France.

The *Belgian, British, French* and *Dutch* Railways operated in Africa and Asia have, in regard to punishments, rules inspired by those which we have just described. These rules, in general, provide either for the intervention of the staff representatives or for the intervention or at least supervision by officials of the Colony in which the railway is situated.

6. *Travelling facilities.*

The railways in many countries, and in particular all the Administrations who replied to our questionnaire, have deemed it expedient to enable the staff to benefit from the efforts accomplished in working the traffic. In other words, the staff of the railways are often permitted to make use of the trains for their personal journeys or those of their families either free of charge or at reduced rates.

Modern life and the habit of making frequent journeys which it implies in all grades of society make this advantage more and more appreciable in the countries where it is granted. The staff attach great importance to these measures and in the travelling facilities afforded them, they find a very valuable material benefit (and that is why we consider that the question ought to be dealt with in connection with the remuneration), when making the journeys which their private interests impose on them, and a benevolent and welcome privilege granted by their employer in the case of jour-

neys occasioned solely by reasons of convenience or recreation.

The system employed on the *French* Railways is that of free travelling facilities granted in a limited number to the employees and their families. The same system is employed with differring methods of application by the *British, Belgian, Andalusian, Dutch* and other railways. In addition to the free passes, it is generally the custom to grant travelling facilities at reduced prices.

The *North of Spain* grants free passes to the employees only and allows considerable reductions for the families.

The *French Colonial* Railways issue a limited number of passes to their employees and their families. On the *Franco-Ethiopian* Railway, the passes are limited to a certain mileage.

The *Belgian* and the *British* Railways of Africa and Asia likewise grant a limited number of passes to the employees and their families. The *Sudan Government* Railways grant facilities for example to the family for holiday journeys when accompanying the employee.

Some Railways outside Europe are obliged to grant very considerable facilities to their European staff for the long periodical leave in the home country.

The *Katanga* Railway states that it refunds the travelling expenses of the employee and his family to enable him to spend his holiday in Europe every three years.

7. *Pensions.*

We have just reviewed the different forms by which the Railways remunerate their staff during the period they are engaged in active service. The Railway Administrations who have replied to our questionnaire have not waited until the social laws of their country made it obligatory for them to provide for the material existence of those of their staff who have passed the age when they can render service in the operation of the railways. Measures have therefore been universally considered to provided the employee who has reached the age of retirement with a pension sufficient to permit him and his family to live.

In *France,* the provisions adopted are the same for all the railways. There is a standard regulation for pensions similar to that which regulates the situation of the employees in active service, the principal terms of which are the following : Every employee who has fulfilled his military service and has served one year on the railway becomes a member of the pension fund of the Railway to which he belongs, and from the date of his joining the fund, a contribution is made to it from the employee's pay. The Railway makes a contribution to the fund which is practically three times that of the employee, the whole of these contributions being employed to provide men who are no longer able to carry out their duties on the railway with a pension calculated in proportion to the active pay and the number of years of service. In *France,* the right to a pension requires the combination of the two conditions : 55 years of age and 25 years of membership (23), the limit of 55 years of age being reduced to 50 for steam locomotive enginemen on account of the special fatigue which this work involves, especially in regard to sight which is of paramount importance for the rapid full perception of light signals.

Half the amount of the pension is revertible to the widow and, if the case arises, to orphans less than 18 years of age, so as to ensure in every case the material life of the family of an employee who, during his active career, assisted in operating the railways.

In order to take into consideration

(23) With special conditions for employees who are obliged to give up their work prematurely due to being invalided, disability, etc.

family expenses which may have prevented the employees from saving out of their pay and thus providing a reserve for their old age, pension increases are granted to ex-employees entitled to standard pensions or invalid pensions (or to their rightful claimants) who have brought up, three or more children to the age of 18. This increase amounts to 10 % of the pension for 3 children and it is increased by 5 % for every child over and above three.

The amount of the pensions provided in France has been repeatedly altered by re-adjustments, so as to enable the staff who ceased their active duties prior to the rates of pay being adjusted in accordance with the cost of living and the value of money to enjoy advantages similar to those of the present staff. As a general rule, the pension rate is 1/50th of the average pay for the three years of greatest earnings multiplied by the number of years of membership. The maximum pension is fixed at 3/4 of the average pay.

The same rules are applied on the *P. L. M.*, Algerian lines.

A certain number of other Railway Administrations apply in their general principles, the regulations just described of the *French* Railways and which are based on the principle of building up the pension fund by contributions by the employees and the Railway in proportion to the pay.

The *Portuguese* Railways are in this class : the receipt of a pension normally implies the double condition of 60 years of age and 30 years of service with a reduction in the age limit for the staff whose duties are particularly severe. In principle, the value of the pension is 65 % of the average pay for the last three years with an increase of 1.75 % for each year of service over 30 years. The level of the pensions granted some years ago has been readjusted as in *France* to the actual value of the wages.

The *Netherlands* Railways require in principle for the payment of the pension the double condition of 65 years of age (reduced to 55 years for certain classes of employees) and 10 years of service. The Company pays 15 1/2 % of the wages of the employees to the Pensions Fund and recovers 8 ½ % from the employees. The rate of the pension is fixed at a figure given by the number of years of service multiplied by 1 3/4 % of the average wages received either during the last three years, or during the last ten years, or during the whole period of service whichever gives the highest amount. The pension cannot exceed 70 % of the average considered.

The *Dutch East Indies* Railways grant pensions to their staff based on the same principles but having different rates according to the grade of the official.

Other Railway Administrations who have replied to our questionnaire have formed their pensions funds solely by payments from the railway. Such is the case of the *Canadian National* Railways who grant pensions to all their employees entering the Railway before the age of 50 and having at least 15 consecutive years of service (excepting special cases).

The same applies to the *Guillaume-Luxemburg* where the staff do not make any contributions to the pensions fund. The right to a pension is acquired either after 10 years of service for employees who are 63 or 58 years old, according to their service or after 25 years of service for employees who have reached the age of 55 or 50 in certain departments. The pension is, in principle, 20/60ths of the basic pay after 10 years of service. It is afterwards increased by 1/60th per year of service to a maximum of 50/60ths. The rate of the pension, like that of the pay of the active staff, varies with the cost of living index.

The *Belgian National* Railway Company grants pensions to employees who satisfy the double condition of being 60 (or 55) years old and having accom-

plished 30 years of service with, of course, provisions for special cases. No deduction is made from the pay to make up these pensions, the rate of which is fixed in principle, per year of service, at 1/55th of the last active pay and 1/48th of the emoluments for the years passed in the active services. Family allowances are likewise granted, the arrangement including the special feature that a deduction of 5 or 6 % is made from the wages of the employees with a view to providing, in the event of their decease, a pension for their widows or their children. In short, a form of life insurance in favour of the family has been founded by the *Belgian* Railways in this way and we have thought this measure worthy of special mention.

On a certain number of *French Colonial* Railways, the special position resulting from the affiliation of the staff to the Intercolonial pensions fund should be noted. This affiliation involves contributions from the staff and the Railway. The amount of pension is fixed by the local branch of the fund without the Railway Administration taking any action.

As an example, on the *Thiès to the Niger* Railway, the contributions of the European staff are 6 % of the wages and those of the Railway are 14 % : the local branch of the fund has organised pensions for the native staff on the basis of equal contributions of 5 % of the wages effected by the employee and by the Railway. The conditions required for pension are, for the European staff, generally 60 or 55 years of age and assume a length of service of at least 25 years of which 15 years have been spent in the Colony. For the native staff, pensions may be paid from reaching the age of 50 years and after 30 years of service.

The pensions paid by the Intercolonial fund were readjusted in 1930 according to the rate of pay of the officals on that date.

The *Franco-Ethiopian* Railways have not established pensions as such, but there is a welfare fund supported by monthly deductions of 5 to 10 % from the pay of the employees, the Railway making equal contributions. The total of these payments together with interests is paid to the employees who leave the railway after more than 5 years service.

The *South African* Railways grant pensions based on a system of equal contributions by the Railway and the employee, to those of their employees who passed a special medical examination at the time of their entry into the service.

The *Andalusian* and the *North of Spain* Railways meet the cost of all contributions to their pensions fund without recovering any part from the staff. The conditions required for pension are 50 years of age and 20 years of service. In principle, the total pension amounts to 1/60th of the average pay for the last 5 years multiplied by the number of years of service. Up to the present, it has not appeared necessary to re-adjust the rate of pensions to the rate of pay of the staff in active service.

The *Gold Coast Government* Railways grant pensions to the European staff reaching the age of 50 with at least 7 years of service in the Colony, and to the native staff reaching the age of 55 and with 10 years of service. All the pensions are paid by the Railways without contribution from the staff. The total pension is proportional to the length of service and to the pay. The maximum pension is 2/3rds of the pay of the staff in active service.

The *Sudan Government* Railways allow their staff to benefit by the general pensions organisation instituted in 1919 by the Sudanese Government.

The employees of the *Federated Malay States* Railways benefit by pensions granted by the Government without deduction from their wages.

The whole of the staff of the *Railways of Great Britain* are assured of receiving at the end of the period during which they are capable of rendering service fo

a railway, a pension providing for their material existence in their old age. However the formulæ adopted for establishing and fixing these pensions differ considerably not only for each British railway but also within one and the same railway for each class of the staff, and in addition a further classification is made according to the age at which the employee entered the railway service.

It is possible in the first place to detect in all these rules the fundamental principle that the pensions of the large majority of the staff are assured with the financial cooperation of the railways, by the English insurance legislation. A small part of the staff called the « Salaried staff », about 100 000 employees for the whole of *Great Britain*, are pensioned by the railway pension funds. The other part of the staff called « Wages staff », comprising about 500 000 employees are obliged by law to contribute to the National Pensions Fund by the system of stamped cards, the Companies and the Government paying their share of the stamps affixed.

The employees affiliated to the railway funds may in general obtain a pension at the age of 60.

Deductions are made from their salary as contributions to the fund. These deductions vary according to the age at which the employee became affiliated to the fund and in all cases are between 2 1/2 and 8 % of the salaries.

The employee who is pensioned off becomes entitled to an income fixed in accordance with variable formulae but which in general is based on the average annual salary for the last 7 years of service.

Some of the *British Railways* have felt that an employee on finishing his active service may require to have at his disposal at that time an appreciable sum of money in order to organise his new method of existence, either to buy a house or to acquire a small business, etc. Therefore, in addition to the annual payment, the pension includes a lump sum payment on retiring and which, in certain special cases that have come to our knowledge may amount to one fortieth of the last year's salary multiplied by the number of years during which the employee contributed to the fund.

The employees who contribute to the National old age pensions fund are treated like all workmen who contribute to this fund. From the age of 65, they receive a pension of 10 shillings per week. In addition, the wife of the employee is also entitled to a similar pension if she has reached the age of 65.

On the *New South Wales Government* Railways, these pensions are constituted by a State fund a deduction of 1 1/2 % from the employees' wages being made.

CHAPTER II.

Social work.

1. *General considerations.*

As will be gathered from the following account, the Railways have always turned their attention to questions tending to improve the material conditions of the life of their employees with a view to ensuring to their staff greater security and increased comfort.

As we have already stated, by acting thus they have fulfilled the social duty incumbent on the employer, but experience has shown that they have at the same time, of course, served their own interests, because a powerful factor in obtaining good operating results is a staff interested in the undertaking, protected as much as possible from both near and distant cares and thus more likely to put into their work their full energy.

2. *What has been done in regard to housing and actual social work.*

The *French* Railways, who have always given attention to these questions,

have followed them up with particular attention since 1918 because housing difficulties began to increase at that time. They have intensified the steps previously taken to render the material life of their employees more easy. The housing crisis, particularly accentuated in certain parts of the country has been effectively met by the railways who have taken steps adapted in each case to the local situation for the benefit of their staff.

Again, railways who have often had to build yards in sparsely populated places or devastated areas have been obliged to build not only houses for private use but in addition all the buildings which are indispensable to the general life of a populated centre, such as schools, dispensaries, baths, etc. They have largely developed their social work in connection with their efforts to provide housing accommodation. We have therefore here a whole series of closely connected problems, and we shall examine what has been done by each railway, under its own special circumstances.

The *Alsace-Lorraine,* during the last few years, has built more than 4 250 quarters housing 10 % of the employees. A certain number of the staff are housed free or account of the nature of their active duties on the railway. The remainder have to pay a variable rent with a maximum fixed at 10 % of the wages.

This Railway has also endeavoured to facilitate the acquisition of property by the employees. Mortgages covered by an insurance on the life of the employee are granted at very low rates to employees who can show that the loan will be used for building a dwelling house for the family.

A number of other measures closely bound up with medical and health questions, regarding which we have spoken previously have been taken with the object of developing cleanliness and immunity from contagious diseases in the employees' families. For this purpose, the Railway invited the collaboration of the Anti-tuberculosis Association of Alsace-Lorraine, to which it pays a subsidy. The sick fund of the Railway has also built an anti-tuberculosis sanatorium by means of grants from the Railway and from the State.

The *Est* Railway provided the first housing quarters for its staff after the 1870 war and has considerably developed its efforts in this direction from 1905 to 1914 and since 1918. It has now placed more than 10 000 houses at the disposal of its staff, of whom 15 % are thus housed by the Railway. For the employees who are not housed free, the rent varies according to the building costs and the localities, although it is always low.

A view of the Manicourt railway town at Nouvions-sur-Meuse is reproduced in figure 31.

The Railway also facilitates the acquisition of house property by its employees by subsidising the building societies and by granting to its employees, if the case arises, advances of pay or mortgage loans intended to facilitate the building of a house. According to the accepted rule in France, these advances are covered by an insurance policy on the life of the employee.

By the 31 December 1930, three thousand advances or mortgage loans had been granted, representing for the part remaining to be repaid a sum of nearly 17 000 000 francs.

A social service with visiting ladies and nurses has been set up in some large centres and gives to the mothers the advice or care which they require. Prenatal medical advice, medical advice to nursing mothers, dispensaries, schools of various kinds and particularly domestic schools are provided for the families of the employees.

The *French State* has gone deeply into the question of providing housing accomodation for its staff and the steps which it is considering and is at present taking

Fig. 31. — Manicourt railway town at Nouvion-sur-Meuse.

are on a large scale. 3 000 houses have been built directly by the Railway and about 1 000 others have been built by the employees themselves with the assistance of loans granted at a low rate by a building society subsidised by the Railway.

A welfare service comprising a staff of welfare workers has the duty of supervising the health of the families and even of giving advice and even discreet help in case of material difficulties or illness which occur in the families of employees and which become known to the welfare service.

A holiday colony with rest house is provided for the apprentices and the children of the railway employees.

The railway in addition subsidises the friendly societies and organises lectures on the subject of protection from contagious diseases. It also provides different schools for the children of employees and in particular domestic schools.

The *Nord* Railway has completed 35 housing schemes which have provided in all 11 000 dwellings for its employees and their families. Including employees whose duties make it necessary for them to be in station buildings, level crossing keepers' houses in outlying places, etc., 20 000 employees and their families are housed by the Company, so that altogether, the Railway has constructed sufficient houses to accommodate 26.6 % of its staff, that is, with their families, a population of 100 000. A view of the Tergnier railway town where there are 1 000 houses is shown in figure 32.

These railway towns are adminis-

Fig. 32. — Tergniers railway town.

tered by a Council on which are representatives elected by the staff which fully appreciate the value of this collaboration. The method has in particular the advantage of developing the spirit of initiative and responsibility in the representatives of the staff living in these towns.

The employees' houses all have a garden. The railway towns when fairly large are provided with primary schools (see fig. 33), maternity centres, kindergartens, housekeeping and other courses, libraries, dispensaries, milk issues, shower baths, sports grounds, various amusements, etc. (24).

(24) The Nord Company's railway town. — Organisation of social welfare hygiene in these towns. — Provision of mobile radiology equipment.

(Flament, *Revue Générale des Chemins de fer*, January 1931).

The Railway Towns of the *Nord* Company at *Longueau*, *Génie Civil*, No. 10, 1st half-year, 1927.

Housing for the staff of the *Nord Railway* at *Saint-Ouen-sur-Seine*, *Génie Civil*, No. 7 of the 2nd half-year, 1929.

Fig. 33.. — Tergniers railway town. Pasteur School.

The employees and their families thus enjoy particularly good living conditions which manifest themselves in a reduction of 19 % in the infantile death rate as compared with that of the same region of France.

With the adult staff too, the average death rate is 48 % lower than that given in the life insurance societies' tables for equivalent ages (25).

In one of its railway towns, the *Nord* Company has installed a holiday colony in conjunction with which there is an open air sanatorium, for very delicate children, situated at Crouy.

A lady superintendent and visiting nurses generally supervise the welfare work and when necessary visit the employees' families at home (26).

Like the other *French* Railways, the Nord grants loans at very reduced rates to its staff to facilitate the acquisition or building of houses. It likewise acts in conjunction with the co-operative societies for building houses of moderate price. 1 700 loans representing a total of about 7 000 000 francs have been made.

The *Midi* Railway provides housing accommodation for 10 % of its staff. The greater number of these are employees who by the nature of their duties are entitled to free housing. Steps have been taken, however, to assist the staff not housed free to find good accommodation. The means employed are various, such as for example advances at a very low rate

(25) See « Demographic investigation regarding the staff of the Nord Railway Company », by Girard, *Revue Générale des Chemins de fer*, June and July 1926.

(26) A film showing scenes of the life in the railway towns will be shown at the Congress.

of interest to employees to facilitate the purchase or the building of houses.

The *Midi* has also made agreements with the building societies in order to enable the staff to benefit by the existing laws dealing with this matter.

The social service welfare work of the Railway has assumed considerable proportions. Dispensaries situated in the large centres are, in fact, open to all the staff and families, pre-natal medical advice, milk issues, etc., are available to the families of employees and have given very encouraging results in regard to the drop in the infantile death rate. Thus, at Bordeaux, this rate for employees' children less than one year old is one quarter of the average rate given under the same conditions by the local statistics. A convalescent home is provided by the Railway at which run down employees may recuperate and avoid illness. Holiday camps have been provided and accommodate a considerable number of the children of employees (27).

A mountain holiday camp is shown in figure 34.

The *Paris-Lyons-Mediterranean Railway (P. L. M.)* inaugurated its first railway town in 1879 at Laroche (fig. 35 shows a play room for the young children of the city) to house its employees and in recent years this railway has considerably extended its efforts.

Including the employees living in station buildings or crossing keepers' houses, nearly 13 % of the whole staff is now housed by the Company. Altogether 15 058 houses are available for the staff and accommodate 51 000 persons in all.

Figure 36 shows the superb situation alongside the international station of Breil, of the French and Italian railway towns built side by side on either side of the frontier.

For those of the staff who by the nature of their duties do not benefit by free housing, the rents vary from 200 to 450 francs per room according to the rank of the employee, the type of house and the rate of living allowance in the locality in question.

The *P. L. M.* has also taken steps to facilitate the purchase of property by its employees. Since 1923 it has granted them mortgage loans and short term advances for building or purchasing a house with garden. As is the case with the other French railways, these loans are covered by a life insurance policy. In certain cases, plots of ground not required for railway purposes have been placed at the disposal of the employees for building houses thereon. From 1922 to 1930, the advances or loans granted numbered 2 700 and amounted to a total of 32 000 000 francs.

This Railway has not failed to organise lectures for instructing the staff and families in questions of health. It shares the expenses of various sanatoria and convalescent homes for the benefit of its staff, and is preparing the installation of a home for old people, the management of which will be entrusted to a private charity called « The Railwaymen's Refuge ».

The education of the employees' families is considerably facilitated by various schools, workrooms, domestic courses, etc.

The *Paris-Orleans* Railway has been engaged for 40 years in facilitating the housing of its employees living in the large towns.

The first step considered with this object in view consisted in lending financial aid to certain private companies formed preferably by groups of employees. The societies benefited by advances made at a moderate rate of interest guaranteed by a mortgage. Since 1920, the Railway, in accordance with

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(27) See the article « The dispensaries provided at Bordeaux and Toulouse by the Midi Company » (Dr. Rivière, *Revue Générale des Chemins de fer*, July 1930).

Fig. 34. — Mountain holiday camp for children of employees of the Midi Company.

Fig. 35. — Welfare centre of the Paris-Lyons-Mediterranean railway town at Laroche. Playroom of Kindergarten.

Fig. 36. — The « Burdanche » railway town at Breil, Paris-Lyons-Mediterranean Company.

the housing laws regarding cheap houses, has given its patronage to the formation of further companies and in addition advances not exceeding 3 months pay without interest but to employees who wish to buy a house individually.

A very highly developed welfare department, run in co-operation with the medical department of the Railway endeavours to reduce the physical and moral difficulties of the domestic life of the employees. Superintendents and nurses or nuns manage numerous milk distribution centres and give, medical advice on pre-natal matters, infantile complaints, etc.

Lectures on health and the prevention of contagious diseases are organised at various centres on the railway and are often accompanied by cinematograph films of an educational character.

A holiday camp has been formed at Quibéron. It receives juniors and apprentices on the railway whose state of health is unsatisfactory or whose reports have been noted particularly good. The children and wards of employees are also taken (fig. 37).

The *Belgian National* Railway Company prior to 1914 only housed the employees who by the nature of their duties were obliged to be always available. Since 1918, the railway has built a certain number of garden cities or has bought houses which are let to the staff at a moderate rental. Altogether, about

5 % of the Company's staff are housed by the Railway and endeavours are being made to increase this percentage.

For many years, the *Belgian* Railways have facilitated the purchase of property by their staff through the agency of building societies who grant loans at a very reduced rate in proportion to the family expenses. These loans are covered by a mortgage on the property built by their aid and an insurance policy on the life of the employee who has contracted them.

The *Great Western* Railway since 1918, has intensified the steps previously taken to facilitate the purchase of property by the staff. Although this Company does not build houses itself, it makes a very considerable effort in regard to the loans granted to the employees with a view to permitting them to purchase houses. In 9 years the loans have reached an amount

Fig. 37. — Paris-Orleans Railway. — Quiberon holiday camp.

of £ 1 120 000 for 2 715 employees. The Company has also made free grants of ground, has laid them out, or has paid subsidies to building societies who build houses for the employees of the railway.

A group of social works of the Company enable the employees to obtain facilities for fresh air treatments, higher education, etc.

The *London Midland & Scottish Railway* (*L. M. S. R.*) has made considerable efforts to facilitate the acquisition of healthy accommodation by its staff. It grants loans for the purchase or building of houses, granting them exceptional liberality in the case of house removals necessitated by duty. In important centres, houses have been built by the Railway and are let to the employees at moderate rents.

The health department of the railway and the medical staff attached to it extend their action beyond working hours in order to cultivate hygienic habits among the employees' families.

The *London & North Eastern Railway* (*L. N. E. R.*) made serious efforts to house its staff when the after war crisis occurred. At that time the Company formed a special building society to which it advanced sums to be employed in building houses which may be purchased by the employees who repay the amount by annual payments. Other private companies have been formed for the same purpose and have received assistance from the building society organised by the Railway. In some cases, the Railway grants direct loans to employees to facilitate the purchase of a house.

The *Netherlands* Railways before the

war only considered it necessary to house the employees who by the nature of their duties were obliged to be always available. Due to the housing crisis which arose in Holland as in other countries, the Railway has bought houses and has subsidised public or private building companies so as to assist its staff in obtaining houses in healthy surroundings at a moderate rental. As an exception, the Railway grants subsidies to employees to enable them to purchase a house of their own.

The welfare work is well developed. The Railway has subsidised associations who run convalescent homes, rest houses, etc., by which the staff may benefit. Children's welfare centres and dispensaries have been established in various centres.

The *P. L. M.* (*Algerian Lines*) have not been able to build houses for their staff because their regulations do not allow them to use any funds for this purpose. Being nevertheless desirous of assisting the housing of the staff, they make arrangements similar to those of the *P. L. M.* proper in order to give pecuniary assistance to the employees who wish to buy or build a house. Short term advances, mortgage loans and assistance to the co-operative building societies have appeared to be the most suitable means of attaining this object.

The *Franco-Ethiopian* Railway places furnished quarters at the disposal of almost all the European employees.

The *Colonial* Railways have had to devote their attention to the housing at least of their European staff and sometimes even their native staff. Local conditions have caused them to develop their efforts in this direction very considerably.

The *Thiès to the Niger* Railway, the *Kenya* and *Uganda* Railway, the *Lower Congo-Katanga* Railway, and the *Gold Coast Government* Railways provide free quarters for their European employees. Steps are taken to facilitate the housing of the natives. Thus, the *Gold Coast Government* Railways house their travelling staff, have built a railway town for the natives who work in the shops and grant the native permanent way employees facilities for building themselves a habitation during the paid working hours. The *Kenya and Uganda* Railway houses 90 % of its native staff.

The *Lower Congo-Katanga* Railway has social welfare services specially organised for the native staff and managed by religious houses to which the Railway grants subsidies.

The *Sudan Government* Railways house about 25 % of their staff who pay a very low rent fixed at 3 % of the cost of building expenses.

The educational development of the native staff is assured by means of technical and other schools.

Of the *Dominion* Railways, the *South African* Railways subsidise a well developed system of welfare work and schools which perform their functions with the aid of the Government and the religious missions. Very extensive measures have been taken ho facilitate the housing of the staff and more than 12 000 houses have been built with this object. The principal depots are provided with rest rooms and bath rooms for travelling employees.

In *Canada*, the lack of housing accommodation has not made itself felt to such an extent as to cause the *Canadian National* Railways to consider this question specially, and only certain classes of employees are housed by the Company. These Railways state that with the assistance of the Y. M. C. A., they have nevertheless taken every step capable of improving the material and moral living conditions of their staff.

On the *New South Wales Government* Railways, railway towns have been built enabling the employees at the large railway centres to find housing accommodation easily. Ground belonging to the railway is placed gratuitously at the dis-

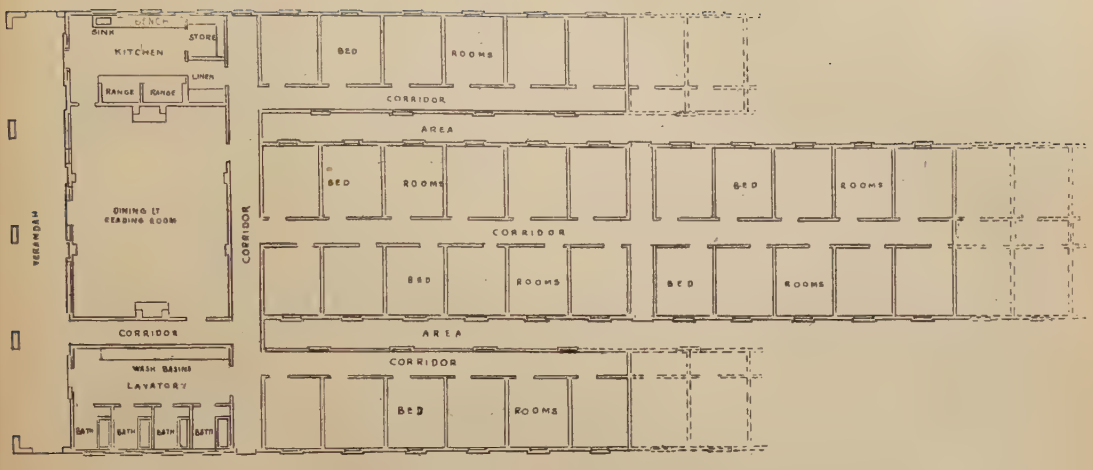

Fig. 38. — New South Wales Government Railways.
Dormitory and eating place for train staff.

posal of employees who desire to build a house. The employees of the permanent way maintenance department are provided with separate tents; in addition sleeping cars enable the staff working on temporary seasonal traffic to be lodged where they are working.

The rest houses for travelling employees are numerous and well kept. They are based on types which can be enlarged (see fig. 38).

The *Asiatic* Railways who replied to our questionnaire have provided information regarding the very extensive measures they have taken to facilitate the material life of their employees.

The *Eastern Bengal* Railway has quite an army of social workers, midwives, etc. Schools have been opened for developing the education of the employees' families and lectures are given to the staff on various subjects with the assistance of private organisations, particularly the Y. M. C. A. The numerous houses built by the Railway accommodate 32 % of the staff, for a rent fixed at 10 % of the wages for the non-permanent staff.

Similar steps have been taken by the *Federated Malay States* Railways who house 40 % of their staff.

3. *Supply of provisions to the staff.*

One of the features of the welfare or social work of the railways which affect the staff most and which merits special consideration, consists of the steps taken to facilitate the supply of provisions or to lower the cost of the necessities of life. The means to which the Railway Administrations, like other large industries, have resorted to may be divided into two different categories :

The most complete measure consists in providing a stores constituting a department of the railway and comprising a sort of general shop selling provisions to the railway employees and their families at cost price, i. e. without the railway making any profit. Generally even the management of such stores constitutes a not inconsiderable expense which the railways carry to lighten the material life of their employees.

Another method of arriving at a

similar result is to form employees' Co-operative societies which, at least in France, enjoy complete independence have their own commercial existence, but benefit by the patronage and even the material and moral assistance of the railways.

This method has been more frequently used of recent years and has the advantage of initiating the staff into the difficulties of all kinds which beset the management of a commercial business, and of acquainting them with the obligations and necessities which every employer has to meet. The employee who is a member of the managing board of a co-operative society thus becomes a « master » when carrying out his duties at the co-operative society, and the duties which he assumes there may assist him to appreciate the usefulness of the measures to which he has to submit as a railway employee, that is to say, as an employee of a large commercial undertaking. These advantages of a moral character have appeared to be so important that some railways have endeavoured to encourage as much as possible the formation of co-operative societies, notwithstanding the difficulties which cannot fail to be experienced by business which, instead of being managed by specialists, is controlled by men who, while being of good will, often lack the necessary time and knowledge. In short, this is a school of practical life instituted under the aegis of the railways, who have to render financial assistance if the business should fail.

The *French* Railways employ both of the methods described above.

The *State*, the *Midi*, the *Nord* and the *P.O.* have formed complete stores in which all kinds of foodstuffs, miscellaneous articles, clothing, fuel, etc., are sold to the staff at cost price by means of an organisation enabling the employee to obtain goods from the supply stores wherever he lives.

The *Alsace-Lorraine*, the *Est*, the *Nord* and the *P.L.M.* have assisted in the formation of employees' co-operatives which take the place of the supply stores on railways where such stores have not been provided and which, on the *Nord*, supplement the facilities afforded by the supply stores.

In addition to these organisations, it has appeared necessary in certain centres to open eating places where the staff unable to take all their meals at home can obtain wholesome and inexpensive food near their work. Here again, the railways have resorted to two methods, either that of organising the eating places themselves or of encouraging the formation of independent co-operative eating places, which, however, the railway assists in various ways so as to lower the price of the meals.

The *French* Railways have established eating places in the centres where the need for them has made itself felt, particularly in Paris where they serve a particularly useful purpose for the employees working in Paris and living in the suburbs, thus obviating the difficulties these employees would experience in having to return home for their mid-day meal, or the appreciable expense which the cost of a meal outside would mean. The establishment of these eating places thus contributes indirectly in remedying the housing crisis in the capital by relieving its congestion to the advantage of the suburbs where it is possible to live at less expense and more healthily. This is one example of the many reactions which the welfare measures introduced by the Railways may exert on each other.

The *L.N.E.R.* has not seen the need for establishing co-operative societies or supply stores but, being prompted by the considerations explained in the foregoing, in centres where a large number of employees are engaged it has opened cantines serving meals to the staff and selling certain provisions.

The *L.M.S.R.* has encouraged the

establishment of co-operative societies formed by the employees themselves as well as co-operative cantines. The Company provides special facilities for running these societies as for example by paying the rent, lighting expenses, etc.

The *Netherlands* Railways have established a co-operative society subsidised by the Company and intended to facilitate the supply of provisions to the staff. They have likewise assisted in the organisation of cantines which are run by temperance leagues.

The *Andalusian* Railways possess a supply stores, and the *North of Spain* Railway which until recently had a supply stores have just handed it over to a co-operative society specially formed by the employees for running it. This new society is subsidised by the Company and uses free of charge the buildings of the old supply stores of the Railway.

The *Portuguese* Railways have opened stores in the most important centres of their lines for supplying the staff with food products and articles of clothing.

The *P.L.M.* (Algerian Lines) have patronised the formation of co-operative societies similar to those existing on the *P.L.M.* Railway itself.

The *Colonial* Railways have taken steps which vary according to the country for facilitating the supply of provisions to their staff, but we have received few details of what has been done in this respect.

The *Thiès to the Niger* Railway, the *Dutch East Indies*, the *South African* and the *Bengal* Railways have organised co-operative societies from which their staff can procure the necessities of life.

Other *Colonial* Railways have resorted to measures in which the Company takes a more direct part, such as for example the opening of covered markets, the opening of stores managed by the Company after the type of the European supply stores.

4. *Recreations: Sports, musical societies, etc.*

We have just made a rapid review of the development of the welfare or social services established by the Railways. We explained in the above how the Administrations have helped in material ways not only the employees housed in the railway towns but also those occupying other living quarters.

In addition to this effort, the railways have taken a number of steps to improve their cities which have tended to make them into small towns where life is not only easy but also amenable.

Healthy, instructive and inexpensive recreations are available to the employees. These recreations, while refreshing the employee permit him to increase his « human » value, either by physical training or by moral training, they are generally available for the families of employees and are organised in such a way that many of them can be used even by the staff not living in the railway town.

Figures 39, 40 and 41 show employees of the *French State* Rys. undergoing courses of physical training on sports grounds of the railway.

The railways for which we are the reporters have encouraged the formation of sports societies, musical societies, etc. among their employees, and the ever increasing success of these Associations shows that wherever they have been founded they have answered a real need. From the social standpoint, they exert an incontestably wholesome effect by affording the staff the recreation which they need in their leisure hours.

These different recreations taken as a whole have a social interest of paramount importance by providing the employees engaged on the same work with numerous occasions to appreciate and get to know one another outside their duties. The bonds of fellowship and comradeship cannot fail to be drawn

Fig. 39.

Fig. 40.

Figs. 39 and 40. — French State Railways. Physical training of apprentices (Rennes sportsground).

tighter and be enlarged, the « esprit de corps » of the employees of a railway is strengthened and brings with it a spirit of emulation which is of value in helping to get the work of the railway carried out satisfactorily.

The social character of these employees' societies is extended even further by competitions or matches between teams from different railways or even different countries which increases the contacts between men doing the same work.

From the human and social stand-

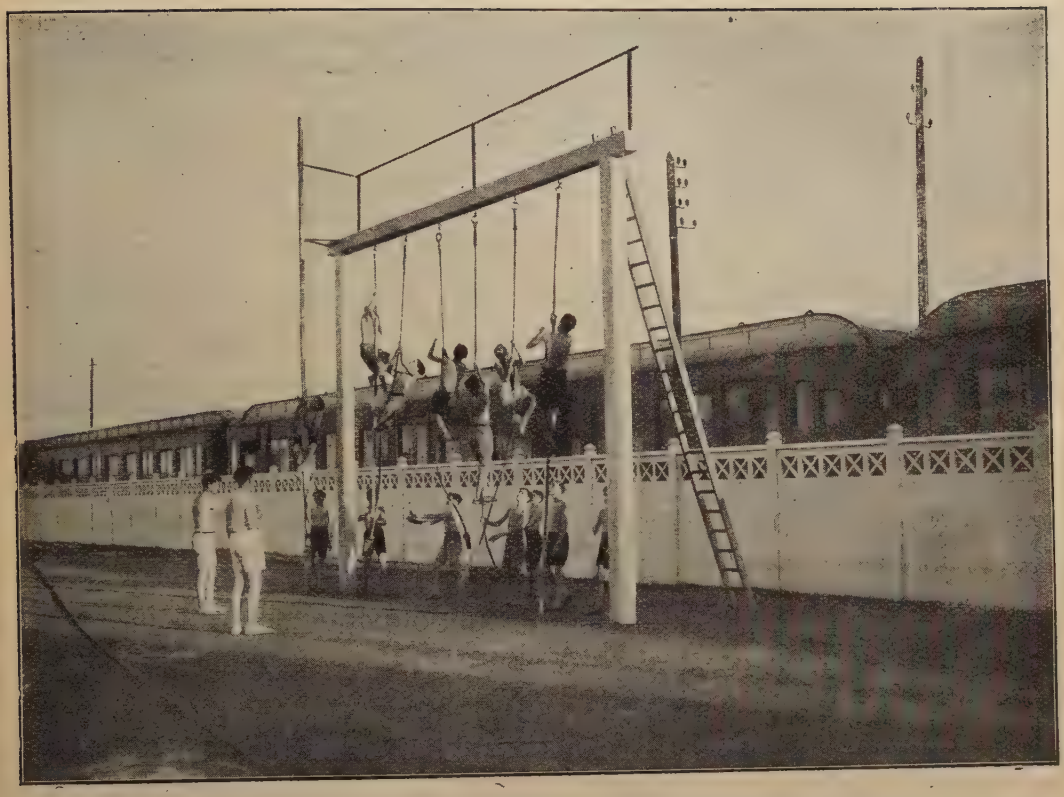

Fig. 41. — French State Railways. Physical training of apprentices (La Garenne).

point, such auxiliary work has quite a different scope from that of simple recreations.

The *Railways of the British Empire* who have replied to our questionnaire make grants to numerous societies having a sporting or educational object : to football clubs, choral societies, musical societies, etc., the membership of which of course is confined to employees of the railway in question.

Similar organisations exist in France and we have received detailed information concerning them. The number of employees' clubs and societies subsidised by the *French* Railways is considerable. A very large portion of the staff are members of these societies which receive from the railways subsidies of a very considerable amount. They also receive assistance in kind in the shape of special travelling facilities, as well as having sports grounds, theatres, cinema halls, concert rooms, etc., placed at their disposal free of charge.

The *Portuguese* Railways state that they grant subsidies and travelling facilities to sports clubs formed by the employees.

The *Gold Coast Government* Rys, the *South African* Rys., the *Eastern Bengal* Ry. and a number of other Railways outside Europe, have formed clubs with sports grounds, rest rooms, etc., placed at their disposal free of charge. These clubs enable the European employees to

meet together after the hours of duty. The native employees have access to these clubs in some cases and are thus able to mix more intimately in the life of their European colleagues. Wherever such mixing has not appeared feasible, special recreations are provided as far as possible for the native staff.

5. *Instructive recreations.*

In order to complete the steps taken in order to provide occupation for the staff during their leisure periods, the railways have put into practice measures for facilitating the recreation which is most capable of broadening the mind of the employee, namely reading. Such reading may have a general scope, and include all subjects, or it may be solely for relaxation; it may however relate more directly to the work on which the employees are engaged.

One of the first measures employed by numerous Railway Administrations consists in publishing periodically a magazine containing information under a variety of headings but having for its chief object the initiation of the employee in the whole of the railway service by providing him with a general idea of those branches of the service in which he is not directly engaged.

The *Railways of the British Empire* have for a long time published magazines intended specially for their employees.

The *Netherlands* Railways, for the same purpose, subsidise a review published outside the railway but distributed among the staff.

The same applies to the *Portuguese* Railways who publish an illustrated review for the use of their staff. This review appears monthly and contains articles carefully got up and of a nature calculated to inform the staff on all sorts of questions even outside the railway sphere.

Some French Railways employ this method. The *P.L.M.* brings out a review every two months which is distributed to all the staff and constitutes a small professional and home encyclopedia, the place of honour being occupied of course by articles having a general bearing on questions concerning railway operation.

The *Paris-Orleans* who for some years has issued a monthly review for the apprentices of its rolling stock and locomotive running department, has now published a review of a general character which is distributed free to all its employees as well as to the retired staff who wish to have it.

In the same spirit, a large number of railways have organised libraries or travelling libraries so that those of their employees who wish to do so may obtain free of charge or at little cost instructive or entertaining books.

Among the railways who have replied to our questionnaire on this point, the *British* Railways have furnished information regarding the fairly complete organisation which they have set going to place books at the disposal of their staff.

The libraries of the *L.M.S.R.* are organised by the employees themselves in buildings provided by the Company. Lectures on various railway subjects assist the employees in profiting by the reading matter placed at their disposal.

The same applies to the *L.N.E.R.* and the *G.W.R.*

Most of the *French* Railways have done much the same.

The *Alsace-Lorraine* has organised libraries at headquarters and at its stations and depots, particularly in centres where the travelling staff may have to stop and may wish to read during their rest periods.

The *Est* has libraries which lend books to the staff in return for a very small subscription.

The *State* has organised in Paris a library of a general character, the books of which may be lent to employees living in Paris or the suburbs. The rolling stock and locomotive running depart-

ment is making a trial of a travelling library. The opinions of the employees regarding this idea are being collected with a view to making the trial general if the replies show that it is useful.

The *Nord*, the *P.L.M.* and the *P.O.* have provided libraries in several of their centres and have instigated the formation of libraries managed by groups of employees with the assistance of the railway.

Outside Europe, the organisation of libraries available to all the staff, both European and native, is particularly useful, and most of the Railways who have replied to our questionnaire have informed us that they had paid special attention to the question. Thus, for example, the *Franco-Ethiopian* Railway has organised libraries which receive a large number of periodicals from the home country, the subscriptions being paid by the Railway. In some colonies, as in the *Dutch East Indies*, these libraries are amplified by lectures intended to develop the general education of the native, and even the European, staff.

The *South African* Rys. who, as we have already stated, have a highly developed system of welfare work, have established libraries in most of their large centres, where the employees on the lines in the neighbourhood may borrow books. In addition, purely technical libraries are provided in two particularly important points on the railway so as to provide employees who so desire it with books for completing their education on all questions which may interest them and which are closely concerned with the working of the railways.

CHAPTER III.

Improvements in the working conditions.

1. *General considerations.*

Among the measures taken by the railways to benefit their staff, are those which aim directly at improving the conditions under which the work is performed.

First and foremost of these steps must be mentioned the natural anxiety of every employer to protect the staff from the dangers inherent to the execution of their duty, that is to say, the prevention of accidents, and methods which safeguards the mens' lives.

In this connection, we have to consider of such measures those which relate not to the improvement of the machines and methods employed, but to the guidance of the employees and to lay down regulations relating to the work which will result in possible danger being avoided. The improvement of the working conditions is thus achieved by an increase in the safety of the staff in carrying out their daily duties and the guiding principles employed on all railways are first of all to lay down such modes of procedure for carrying out each task as are definitely without danger, and then to warn the employees against the consequences of possible imprudent acts so as to ensure that the rules which have been laid down will be carried out.

Another kind of measures which aim at improving the working conditions is to arrange for the staff to undergo medical inspection so that only those individuals will be allowed to carry out a task who are physically capable of doing so, and also to keep the employees in good health after they have joined the railway including, as an amplification of this care, a health service which, according to the local circumstances, it may appear expedient to place at the disposal of, or recommend to, the employees.

Finally, in the cases where they have been recognised as necessary, holidays form a useful means of relaxation and have also been given attention by railway operators as by other employers.

2. *Prevention of accidents.*

Like every employer, the operator of a railway ought to keep first and foremost in his mind the prevention of accidents which, apart from the provision of actual technical measures, assumes two aspects:

— Measures to be taken to instruct the employee of material dangers from his tools so as to protect him against possible imprudent acts.

— Measures of assistance to the injured and their families in cases when an accident has unfortunately occurred.

The *British* and *French* Railways who have replied to our questionnaire all employ very similar measures for the prevention of accidents.

In order to put the staff on their guard against possible acts of imprudence, each employee is provided with a booklet pointing out what he ought to do and what he ought not to do in order to accomplish the usual operations without danger. These instructions are made clear by pictures calculated to attract the attention of all the employees, and particularly those whose education is not sufficiently advanced to enable them to understand very easily the meaning of the text.

These instructions have to be explained to the employees by their immediate superiors who see that they are understood and carried out.

There is, however, a means which is still more efficient than rules for compelling attention, namely visual instruction at the places where danger may arise. The railways have not failed to employ this method and in addition to the booklet, which each employee receives but which he cannot always have under his eyes, posters and warnings worded in the same spirit are displayed in the shops and in the depots, even in the transhipping sheds, so that the employee has under his eyes at the place of danger itself a written warning, often accompanied by a picture reminding him for instance of the danger of crossing the track behind a standing train which may mask the arrival of another. A reproduction of one of these posters is shown in figure 42 and two others intended to impress on the staff the notion of acts which should not be committed are shown in figures 43 and 44.

In *France*, this training of the employees is supplemented by educational films.

The *State* Rys. have instituted « safety weeks » during which the details of the operations performed for example on a piece of work in the shop, are closely examined, and reviewed so that the men doing the work may be alive to the serious danger which may result from a movement that is unnecessary or is contrary to the instructions given.

The *Est* and the *Nord* Rys. give series of lectures backed up by films on the use of the shunter's pole. This new device invented and perfected by the *Nord* makes it possible to couple up wagons without the employees having to pass between the buffers (28).

The *Nord* has formed an accidents committee with representatives of the three departments which investigates thoroughly all accidents of any seriousness either owing to their consequences or to the conditions under which they arise. The Committee has to determine the responsibility in each case and above all to deduce such conclusions as will prevent similar accidents occurring again.

The *Paris-Orleans* has a special accident prevention service which gives the employees safety first lectures quarterly and in due course covers the whole of the staff. According to the statistics of the accidents prevention service, its work has led to a reduction in the number of accidents recorded of:

14 % in the operating department.

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(28) A film on the use of the shunter's pole will be shown at the Congress.

Fig. 42.

Explanation of French terms in figs. 42 *to* 44 :

Fig. 42. — 26 accidents during the 1st half of 1931.
Look both ways before crossing the line.
One train may hide another.

Fig. 43. — Beware of bridges and tunnels.

Fig. 44.— Do not walk in the direction the trains run.

Fig. 43.

Fig. 44.

18 % in the locomotive running department.

12 % in the permanent way department.

In addition, to the efforts made to stimulate caution amongst the employees, a whole series of measures has been taken and are continually being extended by all railways to reduce danger as much as possible. Thus, for example, paths are traced out which the staff walking about are to use in the station, these paths being marked out on the ground with sand or by any other means as well as being shown on a diagram posted up in the station. Similarly, check rails, signal wire posts, etc. over which employees might trip in the night are painted white.

The *Belgian National* Railway Company distributes a special booklet indicating the rules to be observed so as to avoid accidents to the staff who have to move about the line or the sidings.

The Railways have made provision for the injured and his family should an accident take place, despite all precautions.

In *France*, the general legislation concerning industrial accidents applies to the railways and allows the injured person to receive the whole or part of his pay, as well as the necessary attention for curing or making good the injury. A life annuity including family allowances is paid to the victim when his working capacity is permanently affected.

Similar rules are followed in *Great Britain, Belgium, Spain* and *India* where industrial legislation applies to accident cases on the railways as in other industries.

The other Railways who have replied to our questionnaire have not given any details regarding this point, but all have agreed with the principle of giving material assistance to the employees who are hurt when working and to their families (29).

In regard to giving the injured first aid which may have considerable influence on the future development of the injury, the Railways instruct their staff on what is to be done immediately in case of accident while waiting for the doctor. These instructions are repeated in illustrated posters provided at the working places. For example, instructions in poster form explain to the employees how artificial respiration is to be carried out without delay in case of electrocution and special apparatus is ready and stored in places where this risk is greatest.

2. *Medical attention.*

As employers of a very considerable staff, the Railways owe to society and their country the duty of developing as extensively as possible the means placed at the disposal of their employees for keeping themselves in good health. This solicitude extends more or less to the members of the family according to the country and the local requirements.

Guided by these principles, the Railways have all taken steps to have medical organisations available, the forms of organisation being different, but all of them being so adapted as to meet in the best possible manner the local requirements experienced in each particular case.

Irrespective of the form of organisation of the medical service in each case, its first duty everywhere is to examine the physical condition of the candidates for employment on the railway (30). The new formula of the

(29) Some Railways, amongst which the *French Nord*, have set up special welfare organisations for improving in every possible way the condition of the children of men killed or injured while on duty.

(30) See Report on Question XVI of the Madrid Congress.

psychotechnical examination, that is to say, the physical examination as to the capabilities of the individuals to hold certain employments and on their reactions under well-defined conditions is taken into consideration by the railways.

The Dutch East Indies Railways carry out a psychotechnical examination on applicants for employment in the permanent way or locomotive running departments.

The *French Nord* has commenced to employ the method and expects to develop its use.

There are three different forms of organisation of the medical service:

— The first method consists in organising within the railway an independent medical service which looks after the employees and in certain circumstances their families.

— The second method consists in resorting to independent funds which may be started by the railways, or in forming societies of the nature of benevolent or friendly societies.

— The third method is to resort to the Government in countries where medical assurance is under Government control.

The majority of the *French* Railways adhere to the first method although in some special cases they employ the second. All of them have a complete medical service which gives medical attention to the employees free of charge. Prescribed medicines are given free of charge to all employees whose wage does not exceed a certain amount. The same applies to hospital treatment when such treatment is necessary.

In principle, free medical attention is not extended to include the families, but private services organised either by the railways or by the employees permit the subscribers to receive assistance in kind or cash in the event of illness in the family. The *French* Railways in such cases employ the second method by generously assisting such services which are mostly of the character of friendly societies.

The *French* Railways have also established or have contributed towards the establishment of sanatoria and hospitals and collaborate in various forms in fighting tuberculosis.

Those of them who do not possess a sick fund considerably extend their statutory obligations in regard to employees afflicted with a serious illness. These benevolent measures deal with :

1. The extended payment of the whole or part of the pay according to scales taking into consideration the situation and the expenses of the family.

2. Medical attention including hospital treatment which, when it is necessary, is paid for by the Railway, either definitely the whole (*Nord*) or with recovery of part of the cost (*State, P.O.* and *P.L.M.*).

3. The grant of aid when the request is justified taking the expenses of the sick person into consideration.

4. The contributions of the employee to the pension fund which the *Nord* pays until the recovery, discharge or decease of the employee.

These arrangements include tuberculosis for the four railways under consideration and are extended to include all sickness on the *Nord* and the *P.L.M.* The *Nord* has also organised a special service called the « serious sickness service » instructed to follow closely the application of these arrangements.

The *Belgian National Railway Company* has organised a mutual insurance fund which provides the staff with numerous advantages, even assistance and in particular medical attention and medicaments. This fund which the Railway provides is managed by a « national headquarters committee » composed of ten delegates from the Company and ten

Fig. 45. — Interior view of an ambulance wagon of the Canadian National Railways.

delegates from the recognised staff organisations.

The *North of Spain* has organised a medical service. It distributes medicaments free of charge to the employees whose wage is below a certain amount. The families of employees can obtain medicaments at a reduced price without being able to claim medical attention. Hospital treatment is facilitated in various forms.

The *Canadian National* Rys. and the *New South Wales Government* Rys. have their own medical services and both mention the interesting innovation of running over their lines a car specially equipped for the periodical examination of the sight and hearing of the employees engaged on work affecting safety.

In addition, the Canadian National Rys. have ambulance cars running in sparsely populated districts of the railway (fig. 45). These cars are equipped so that they can be converted into rooms where

the travelling medical staff lecture the employees on health and the first aid to be rendered to the sick and injured. This railway has also built hospitals for the requirements of its staff.

The *Portuguese* Railways have a medical service which gives free attention to the employees and their families, as well as certain medicaments.

The *African* and *Asiatic* Railways have not failed to take the local requirements into account and they have or can call upon medical services capable of keeping their European staff in good health and of reducing the death rate of their native staff who are often still ignorant of health matters. Thus the *Franco-Ethiopian* Railways and the *Belgian Congo* Railways have complete medical services and provide all their employees engaged in the country with free medical attention and medicaments, even providing hospital treatment on the spot when this is necessary. The same applies to the *Eastern Bengal* Ry., the *Federated Malay States* Rys., etc.

The Railways of the *Reunion Island* have their medical service which attends free of charge the employees only. Free hospital treatment is as a rule reserved for cases of endemic disease.

The second method is employed by some *French* Railways. Since 1856, the *Midi* Railway has had a welfare fund of which all the employees whose wage remains within a certain limit are members. Membership of the fund is optional for the other employees. This fund is supported by a stoppage of 2 % of the wage of the employees and by payments by the railway. It provides the members with free medical attention, medicaments, appliances, etc. and also funeral expenses and assistance for widows and orphans. It likewise allows sick workmen full pay for a certain period, free hospital treatment in the Company's rest house and a considerable portion of the hospital expenses in other institutions, as well as absolutely free attention in all the dispensaries of the Midi Company. A view of the open air sick ward of the rest house for the employees of the Midi Company at Enveigt, Eastern Pyrenees, is shown in figure 46.

The Midi has created a vast organisation for the detection and treatment of syphilis. It may be noted in passing that apart from the social duty thus accomplished, this railway has had the satisfaction of recording a considerable gain in working days as compared with the number of days of sickness lost annually by the staff before this organisation was instituted.

The *Alsace-Lorraine* possesses a railway sick fund which permits free medical and pharmaceutical attention in certain forms to be extended to the families. The same principles are applied by the *Guillaume-Luxembourg* provisionally operated by the *Alsace-Lorraine*.

The *Est* Railway has also a purely optional welfare fund of which the employees may become members by payment of 1 % of their wages. Membership of this fund provides the staff with considerable advantages in the case of sickness or injury outside their employment. In addition to absolutely free medical and pharmaceutical attention, hospital treatment is provided for all the lower grade staff. The working pay is paid to the sick or injured employee for a variable period which, however, considerably exceeds the period laid down by the statutory regulations. A view of the Sérigourt Hospital is shown in figure 47.

The *Netherlands* Railways have established a relief fund which is obligatory in the case of staff whose pay is below a certain level, and is optional for the others. The working of this fund provides advantages similar to those which have just been described for the *Midi*.

The *South African* Rys. have created a « sick fund » appointed to administer the medical service. 75 % of the expenses are paid by the Railway and 25 % by the

Fig. 46. — Medical treatment balcony of the rest house of the employees of the Midi Railway at Enveigt (East Pyrenees).

Fig. 47. — French Est Railway. Hospital at Séricourt.

staff, whose representatives take part in the administration of the « sick fund ». This organisation provides free medical attention and to a certain extent pharmaceutical attention for the employees and their families.

The third system of medical attention provided by a State organisation is employed in *Great Britain* where the « railway » medical service is only employed to ascertain whether candidates have the physical capacities for admission to the railway, whether they retain such capacities and to make certain that the illness is real.

The clerical staff, however, is not insured by the State against sickness. Medical attention and the expenses of hospital treatment are then covered by a « Railway » fund supported by equal payments by the employer and the employees.

In *Belgium* the hospital expenses of the employees are in certain cases borne by the « social insurance fund ».

Numerous railways operating *outside Europe*, particularly those of the *Dutch East Indies, Ceylon,* the *Sudan,* etc., make use of the official medical services.

3. *Hygiene.*

After having protected the employee from material accidents, the railways have introduced a whole series of measures with the object of protecting him from sickness, in so far as it is avoidable, that is to say, in so far as it constitutes a social accident.

The *French* Railways have set up health committees or have instructed their medical service to supervise the hygienic conditions of accomodation assigned to the staff. Sometimes this is done by a headquarters committee, as on the *Nord* and sometimes, as on the *Alsace-Lorraine,* there is a committee at each area centre.

The *Alsace-Lorraine* and the *P. O.* cause lectures to be given to their staff in order to remind them of the steps to be taken for protecting them from contagious diseases, particularly syphilis and tuberculosis.

Anti-tuberculosis services have been organised by the numerous railways who replied to our questionnaire. These services have the common feature of being formed not only for the employees themselves but wherever possible for their families with the aid of visiting nurses or welfare workers.

The forms of organisation are very varied depending on the needs of each case as well as on the assistance the railway may be able to call on through associating its efforts against tuberculosis with that of the official organisations of the country.

Thus, the *Nord* has just put into service a travelling radiological equipment enabling early cases to be detected in outlying localities and without moving the sick persons. This equipment also renders great services in the treatment of the injured (31). A view of the interior of the radiological car is shown in figure 48.

These services have made it possible to give cases the needed attention in preventive institutes in time and thereby save many lives.

All the *French* Railways have provided dormitories, refectories and shower baths, in which their locomotive and train staff may rest and relax when off duty away from home. In the large centres, these dormitories provide acco-

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(31) See : The Railway towns of the Nord Railway. — Organisation of social hygiene in the cities. — Formation of a travelling radiological unit : Flament, *Revue Générale des Chemins de fer,* January 1931.

Fighting tuberculosis on the Nord Railway : Dr. Hirschberg and Dr. Rivet, *Revue Générale des Chemins de fer,* January 1932.

The radiological car of the Nord Railway : Dr. Hirschberg, *Journal de Radiologie et d'Electrologie,* Aug 1931.

Fig. 48. — Radiological train of the French Nord Railway.
Perspective view of the radiology room.

modation where the employees during rest periods can find shelter and entertainment while awaiting their turn to go on duty again.

The *Belgian* Railways leave to their medical service the supervision of health questions. They also possess refectories, dormitories, and shower baths for the locomotive and train staff.

The *North of Spain* leaves to the local

heads of departments the duty of seeing that the rules of health are properly observed. As in France and Belgium, quarters are placed at the disposal of the train staff.

The *London Midland and Scottish* Ry. has organised a health service which looks after the installations of the entire railway and has a considerable staff. This health service extends its operations outside working conditions and consequently its duties are involved in the social work to be discussed later.

There are, of course, dormitories and shower baths at the disposal of the train staff.

The other Railway Administrations who have replied to our questionnaire have also provided arrangements similar to those just described, for looking after the health of their train staff and other employees.

The Railways operating in *Africa* and *Asia* have studied with special interest health questions with a view to providing their European employees with healthy quarters so as to help them to adapt themselves to the new climate. They have also directed their health services to educate their native employees and the replies we have received show that such points of view have been studied very closely. In particular, the *South African* Rys. make arrangements for their technical staff to inspect the healthfulness and convenience of the quarters assigned to the whole of the staff. The *Federated Malay States* Rys., *Eastern Bengal* Rys., etc., have health organisations which, wherever necessary, take special steps for protection against endemic diseases, the treatment of such diseases being covered by the medical services, the organisation of which we have just been considering.

4. *Holidays.*

The railways have attached importance to dividing up the working periods by days of rest. They have considered it necessary to permit the employees to break off work periodically and the methods of carrying this out have been fixed in each case after a close study of the local conditions and the nature of the work.

Like all employers, the Railways have also considered that they ought to respect the family obligations of the staff outside their working hours and which they ought to be able to satisfy by being granted leave.

It would moreover, appear that leave thus granted to the staff, based on broad social ideas, is a powerful aid in attaching the staff to the railway. It has had in addition a favourable influence on the efficiency and the working capacity between leaves, and in certain cases, this fact may to some extent compensate the railway for the heavy sacrifices imposed on them by their granting holidays to the staff.

A first step in this direction and one which is of absolutely general application, consists in allowing the employees to have their Sundays and holidays, with of course the arrangements by rota which are necessary to ensure continuity in the service.

On the *French* Railways, the permanent staff also benefit by an annual leave with pay, the length of which varies with the grade and which at the most is equivalent to a calendar month. Similar measures are taken by the other Railway Administrations who have replied to our questionnaire. Some of them do not grant leave with pay to the shopmen who are however allowed leave as far as is compatible with the necessities of the service.

In regard to the *Colonial* Railways, the arrangements relating to leave are applied as regards the native staff under conditions similar to the system in the home country, this in particular is the case of the *Thiès to the Niger, Reunion Island,* the *Dutch East Indies,* the *Gold Coast,* etc., Railways. The same pro-

cedure cannot be followed in the case of the European staff, and it has been necessary to adopt quite different regulations enabling this staff to recuperate from time to time in the mother country. It must therefore be possible to combine the holidays so as to permit the employee and his family to stay for a sufficient length of time in Europe in order to make up for the expenses of the journey. The holidays are not annual but are spaced at wide intervals.

Thus, the *Gold Coast Government* Rys. grant to their European employees a week of leave for each complete month of active service in the colony, and in addition the time necessary for the journey. The frequency of the leaves is fixed at 18 months.

The *Franco-Ethiopian* Railways grant 3 to 4 months leave every three years with pay and all cost of living allowances.

CHAPTER IV.

Collaboration of the staff in the operation of the railways.

1. *General considerations.*

The staff being closely concerned in the working is able, in a spirit of collaboration, to furnish information and bring forward ideas, the application of which is of benefit to all.

A valuable method of attaching the staff to its railway undoubtedly lies in seeking to develop this spirit of collaboration by showing the employees that their suggestions can result in an improvement or simplification of the service.

The interest attached to these suggestions has therefore an educational and moral result at least equally as important as the practical result to be expected from them, because the employees, knowing that their suggestions if of value will be welcomed and considered, are encouraged to make them and by that very fact, to study more closely the working of various methods which they employ.

2. *Representation of the staff.*

As we pointed out previously, the whole of the rules which define the relations between the railways and their staff : remuneration, promotion, discipline, etc., have in certain cases formed the subject of an agreement carried out with the collaboration of the representatives of the employees. Once completed this agreement inevitably gives rise to differences in interpretation for special cases, or it may, according to circumstances, call for additions in order to adapt it to new conditions. In order to settle all these questions arising out of the application of the agreement, when such exists, it has appeared advisable to invite the representatives of the staff to continue their collaboration with the representatives of the railway. This method offers a threefold advantage :

— to enlighten the railways on the wishes of their employees and consequently to enable them to take such aspirations into consideration as far as possible.

— to enlighten the employees through the medium of their representatives regarding the reasons which may incline the railway towards one solution or another, and consequently to induce them to accept with a thorough knowledge of the matter the solutions to which their representatives have already agreed.

— finally, by this constant collaboration, to bring about a closer contact between the employers and the employees and thereby to foster a mutual esteem essential for the satisfactory working of the railways.

The *French Railways*, in their agreement, have provided for the representation of the staff. Delegates elected by the employees are nominated to the district heads of departments, the heads of the principal departments and the general manager of each railway. These

delegates give their opinion before general instructions bearing on the application of the staff agreement are put into force. They examine complaints submitted by the employees when the staff reports are drawn up and approve the tables of ability used for their grade promotions.

They are qualified to express the wishes of the staff concerning the organisation of the work, health, safety, and all local questions which may arise, questions of a general character being excluded.

The delegates are called together periodically by the departmental head to whom they are accredited and these periodical conferences establish a direct collaboration facilitating the solution of all kinds of questions affecting the department in itself, to the exclusion of course of questions of management.

The *Belgian National* Railway Company has organised the representation of its staff on different lines, the principle of which is the recognition of and intervention by the staff associations whose statutes have been submitted with the names of their responsible leaders. These groups are allowed to intervene in writing or verbally with officials of all degrees from the man's immediate chief to the board of directors.

The *British* Railways have a very complete organisation ensuring permanent contact between the management of each Company and its staff.

The arrangements adopted include two systems of representation of different characters, according as to whether it is a question of the salaried staff or the workmen. In the first case, there are local departmental committees composed of the local departmental heads and the representatives elected locally by the staff of all classes. Above these local organisations, area and all line councils have been formed, composed of the departmental heads and the representatives elected by the staff in the various branches of the service : locomotives, passenger traffic, goods traffic and permanent way.

In regard to the shopmen, an independent but similar organisation has been instituted which also includes two stages of local councils with a higher council for each railway, all of which are composed of representatives of the railway and representatives elected by the staff.

The *Guillaume-Luxembourg* has provided a staff representation in two degrees with the local departmental heads and the management. This representation is provided for each of the operating, rolling stock and locomotive running and permanent way departments.

The *Netherlands* Railways properly speaking do not have any representation of the staff but they allow the representatives of their employees to intervene in certain matters and a « staff council » composed of delegates of the trade unions is called upon to consider matters dealing with the application of the agreement.

Among the railways operated outside Europe, the *P. L. M.* (*Algerian Lines*) employs the same statutory arrangements as the *P. L. M.* of *France*.

The *Franco-Ethiopian* Railways and the *Dutch East Indies* Railways have instituted a system of staff representation by delegates. The *Reunion Island* Railways restrict the representation of the staff to the participation of a delegate in the administrative council in, moreover, a purely advisory capacity.

3. *Suggestions of the staff.*

Until recent years, it was not thought necessary to institute a special organisation for collecting the suggestions which the staff might have to submit in order to improve the working of their railways. The *English* and *French* Railways, however, who have replied to our questionnaire have pointed out that they have special organisations for this purpose :

The *L. N. E.* Railway and the *G. W.* Railway ask the staff to send their sug-

gestions under sealed envelope direct to a special office under the general management of each of these Companies.

The *L. M. S.* Railway has made similar arrangements and inform us that during 1930 the number of suggestions submitted was 10 622, of which 1 088 have already been adopted. The *British* Railways grant special bonuses to employees who have submitted suggestions necessitating personal effort on their part and marking particular interest given to the improvement of the service.

The *Canadian National* Railways and the *New South Wales Government* Railways have formed a special committee appointed to collect and examine the suggestions of the staff.

In the various establishments of its railways, the *French Est* has installed « suggestion boxes » in which the employees may put their suggestions. During the years 1929 and 1930, the number of suggestions submitted was 3 031, of which 530 have been used. Naturally, each suggestion which is used entitles its author to a special allowance intended to reward the initiative he has displayed, but most often the authors of suggestions which are turned down receive gratuities on account of the interest they have evinced in the improvement of their department.

The *P. O.* about fifteen years ago placed « suggestion boxes » in its shops. Since that time, it has standardised the method for putting forward the suggestions of the staff. It derives numerous advantages from this organisation.

The *French State* applies similar arrangements in the form of a special organisation attached to the management to which the employees may communicate their ideas either directly or through their heads of department.

The *P. O*, the *P. L. M.*, the *Alsace-Lorraine* and the *Nord* have not considered it necessary to create special organisations for examining the suggestions of their staff, but they encourage them by premiums or special bonuses or by the Company paying for patents intended to guarantee to the inventor the property of his invention (32).

The *Midi* has just created a special organisation for collecting the suggestions of the staff.

On the *P. L. M.* (*Algerian Lines*) the suggestions of the staff are examined during the periodical conferences with the staff delegates.

The *North of Spain* collects the suggestions which the employees can always put before their superiors and follows up those which appear to be of some value.

The same applies to the railways of the *Dutch East Indies*.

CHAPTER V.

Professional training.

One of the obvious conditions of good efficiency is that the railway shall have at its disposal a staff physically and intellectually capable of fulfilling its duties. This involves a whole group of questions relating to the recruiting and training of the staff which are extremely interesting from the point of view we are at present considering, but to which we do not think we ought to return, seeing that the question was dealt with thoroughly when considering Question XVI at the Madrid Congress (33).

The recommendations which the Madrid Congress formulated are briefly as follows :

1. To recruit only candidates who possess the qualities necessary for the duties they will have to perform, to make sure they have the necessary general education, if need be

(32) This is what the *French Nord* and the *New South Govt.* Rys. do.

(33) See : Methods followed in training of staff, professional, technical and ordinary working grades. Reports, Madrid (1930) Congress, Question XVI.

making them undergo special examinations, such as psycho-technical, to which special attention was called.

2. Before the employees engaged begin their duties, to train them practically, this preliminary training varying in character and duration according to the character of the position to be held.

In regard to apprenticeship: to train apprentices so that they may have as good a professional training as the manual workers in other industries of the country, and in countries where there is compulsory military service take back by seniority the apprentices trained before they went into the army.

3. To develop the professional training of the employees in service and give them practical instruction concerning the steps to be taken in case of accident. To make certain continually that the staff has thoroughly assimilated, and makes use of, the matter taught.

4. To assist as far as possible private institutions intended to facilitate the training of the staff and to recommend the development of education by correspondence courses.

5. To facilitate the admission of the best of the employees to superior posts.

All these recommendations which met the situation existing at the time of the Madrid Congress, have been followed entirely by the Railways wo replied to our questionnaire. Their replies unanimously show care in recruiting only staff physically and intellectually capable of holding their positions, and in developing, at considerable cost to the railway, every means to enable the staff already engaged to strengthen and complete their theoretical and practical training.

Moreover, we have not found anything, in the replies received, of sufficient novelty and interest to be quoted as an addition to the reports submitted at Madrid.

The most important question from the point of view we are considering here is certainly that of the psychotechnical examination, of the applicants, or at least of applicants for certain posts. We have already said that among the Railways who replied to our questionnaire, only the Railways of the *Dutch East Indies* and the *French Nord* have reported that they are putting this method of examination into practice.

General summary.

In this report, we have examined successively the methods employed in order to improve the working processes and to increase the interest of the staff in the railway employing them.

The general ideas to be deduced from our report appear to us to be the following:

1. — It is necessary to avoid all waste of effort, and for that reason it is essential to investigate every possible means of strenghthening the co-ordination between the railways and the departments with a view to increasing the efficiency.

The mechanisation of river transport, the increase in road transport and even aerial transport render the application of such measures more needed than ever.

The freedom enjoyed by these different forms of transport both commercially and technically, enable them to utilise without delay and completely the improvements which their initiative or modern technique places at their disposal. It would be highly desirable moreover for the same freedom to be granted to the railway.

2. — It is desirable that every employee should be made aware of the part he plays in his railway as a whole. Routine operations will be rendered automatic as far as possible, every employee will be relieved from looking after mechanical tasks, his freedom of mind will be increased and his qualities of initiative and inventiveness will be developed.

In this way it will be possible to de-

velop in the staff a sense of the importance of the duties each covers and at the same time to enable all the employees to do creative work and thus contribute with all their ability to increasing the efficiency of their railway.

3. — As concerns the administrative organisations in particular, their work must be facilitated by reducing to a minimum the intermediate organisations separating them from the executive organisations. This simplification, scientifically carried out from top to bottom should be assisted by a sort of lateral simplification, obtained by the interpenetration and co-ordination of the separate departments which take part in the working of the railway. It is for this reason that we have drawn attention to the value of periodical conferences and meetings between departmental heads. In fact, we consider that there is nothing so qualified to get good team work as frequent personal contact between the officials responsible for part of an undertaking.

These periodical conferences will be replaced by joint, permanent organisations when the desired co-ordination assumes a permanent character.

4. — In regard to the executive organisations, they must be enabled to collaborate in discovering the methods giving the most economical and most certain results. To this end, it is recommended to adopt the principles of functional control, that is to say, to develop the specialisation of the employees. If the duties of each man are within close limits, he will accept more willingly a responsibility the limits of which he knows. His capacities will develop rapidly within these limits and he will eventually collaborate in the common task more effectively with a view to obtaining the optimum efficiency.

5. — A necessary corollary of these improvements in the organisation will be the simplification of the executive operations themselves, this simplification being obtained either by improvements in plant so as to obviate useless operations and loss of time or by better materials, machines and tools.

6. — After having, by these measures as a whole, placed at the disposal of the staff as perfected an equipment as possible, a ready collaboration on the part of the staff may be hoped for and what is better still a spontaneous contribution of collective good will based on mutual esteem, and on payment, taking into account the efforts made and the results obtained.

7. — Trained employees capable in every way of fulfilling their duties are also required as shown by the conclusions adopted by the 1930 Congress following the examination of Question XVI of its agenda.

8. — All the Railway Administrations have made serious efforts to attach their staff to their employer and interest them in their individual work. An important number of measures have already been taken or are being developed, which we have commented upon at length and which, as experience has shown, have given happy results.

These measures, of many forms, ought we think to be inspired by the following guiding principles :

a) To increase the mutual confidence of the employees of all grades so as to render more and more close the collaboration of the staff in all the stages of the organisation, and to develop in all the sense of professional duty in its widest human sense;

b) To prolong this purely moral action and to confirm it by work revealing the spirit of fellowship uniting the men in carrying out a common duty. For this reason, it is desirable to facilitate as far as possible the material life of the staff and to endeavour to protect it from risks capable of affecting it;

c) Finally, to develop by all the means in the railway's power the general instruction and the moral welfare of their staff and for that purpose to help in setting up educational or sports institutions.

All these efforts will result in an increase in the human value of each employee a growth in him of his social sense, of comradeship and *esprit de corps.*

APPENDIX I.

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Madrid Session, 1930 :

Question IV. — Recent improvements in permanent way tools, and in the scientific organisation of maintenance work.

Question X. — Methods to be used in marshalling yards to control the speed of vehicles being shunted and to ensure they travel onto the lines in the various groups of sidings.

Question XIV. — Use in railway work of machines for simplifying statistical and accountancy work.

Question XV. — Co-operation of the staff towards increased efficiency and its participation in the profits.

Question XVI. — Methods followed in training of staff, professional, technical and ordinary working grades.

Cairo Session, 1933 :

Question II. — The use of mechanical appliances in the permanent way maintenance and in track relaying.

Question VII. — Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round.

APPENDIX II.

List of cinematograph films to be shown at the Cairo Congress.

— The shunter's pole used on the *Nord* and the *Est* Railways.

— Organisation of marshalling yards on the *Est* Railway.

— Organisation of a suburban service on the *Est* Railway.

— Organisation of work in the *Paris-Orleans* shops.

— Track relaying on the *Nord* Railway.

— Life in the railway towns of the *Nord* Company.

[621 .43]

The new rail motor coaches with internal combustion motor,

by Max BREUER,
Reichsbahnoberrat, Berlin.

(*Zeitschrift des Vereines deutscher Ingenieure*, 23 January 1932, Vol. 76, No. 4.)

The increasing importance of rail motor coaches, and the influence of the more pressing demands of the service on the constructional forms of these vehicles, will be examined below in their various aspects, covering a series of examples of new types adopted for main lines and secondary lines.

The new orientation lies in the tendency to increase as far as possible the driving power relatively to the weight of the vehicle, so as thereby to reduce the journey time.

At the same time, consideration will be given to the repercussions of the increase of speed on the permanent way and on the working of the lines.

* * *

Since the last important orders were placed by the German State Railway Company (Reichsbahn) during the period 1925 to 1927, for rail motor coaches with internal combustion motors, operating conditions and the needs of the service have been modified to such an extent that it has been necessary to evolve new types of rail motor coaches. At that period (1), the speed of rail motor coaches did not exceed 60 to 65 km. (37.3 to 40.4 miles) per hour. Such a speed, while sufficient for secondary lines, was inadequate for main lines. None the less, this speed was then adopted, in spite of its not being adequate for all lines, because a higher speed for main line rail motor coaches would have necessitated the use of more powerful motors and the construction of a new type of rail motor coach, and this, during the first phase of development, was not desirable. It was necessary, indeed, at that time, to take into account the degree of progress achieved with internal combustion motors, particularly Diesel motors.

Two-axle rail motor coaches, with 50 seats, tare weight from 18 to 20 tons, were equipped with a 75-H.P. motor, and eight-wheeled rail motor coaches, with 80-90 seats, tare weight 40 tons, were equipped with two 75-H.P. motors or with one motor of double capacity. All the rail motor coaches of that period had mechanical transmission, because electric transmission, although advantageous from various points of view, was too heavy and too expensive and because, the horse-power being relatively low, mechanical transmission was still adequate (2).

In the meantime, competition by road motor cars and motor coaches has increased to such an extent that the Reichsbahn has found itself compelled to seek for new means of arresting the decline in its traffic. As frequency of services and speed are obviously the first desiderata of the public, it has been neces-

(1) *Zeitschrift des V. D. I.*, vol. 70 (1926), p. 1034; G. Naske, *Zeitschrift des V. D. I.*, vol. 72 (1928), p. 1605.

(2) For the working results with these rail motor coaches, see Student, *Reichsbahn*, vol. 4 (1928), p. 922.

sary to approach the problem mainly from this double point of view.

The reasons which up to the present have militated in favour of the running of relatively few but long trains are, as is well known, mainly of an economic nature. The tendency was to favour a reduction in the net cost of motor power necessary per passenger and the greatest possible reduction in staff. From the moment, however, when the intervals between trains attain a point at which they result in an appreciable decrease in receipts, due to a decline in the number of passengers carried, this tendency can no longer be justified.

From that moment it becomes necessary to increase the number of trains and to intensify the service. There results a greater demand for rail motor coaches, the function of which assumes an increasing importance, as steam traction becomes too uneconomic for light trains. It is obvious that progress can only be gradual having regard to the existing stock of locomotives and carriages; thus, so long as other trains are run on the same line, the new rail motor coaches must observe, at any rate approximately, the same speeds as those trains, as otherwise there would result an excessive complication in the drawing up of time tables.

In view of the fact that, particularly from the point of view of speed, the conditions with which rail motor coaches must comply are totally different according as it is a question of main lines or of secondary lines, there naturally results a clear sub-division of the types of rail motor coaches.

Rail motor coaches for main lines.

The new rail motor coaches intended for use on main lines in flat country should be capable of a speed of at least 90 km. (56 miles) per hour. This requirement entails, it is true, the necessity of having to resort to very much higher driving powers.

The table below, the figures in which relate to rail motor coaches, and which has been compiled on the basis of the results of tests, shows the greater increase in tractive force, relatively to the increase in speed, taking the speed of 60 km. (37.3 miles) per hour as the unit.

The same table shows the still more marked increase in power.

Speed in km. (*in miles*). per hour	60 (*37.3*)	70 (*43.5*)	80 (*50*)	90 (*56*)	100 (*62*)	210 (*75*)
n	1	1.23	1.49	1.76	2.17	2.82
m	1	1.44	1.98	2.64	3.60	5.65

n = ratio of tractive force, corresponding to the individual speeds indicated above, to that corresponding to the unitary speed of 60 km. (37.3 miles) per hour.

m = ratio of the power at the rim, corresponding to the individual speeds indicated above, to that corresponding to the unitary speed of 60 km. per hour.

It must, however, be noted most particularly that these figures are only applicable to a certain type of vehicle. They apply to running under working conditions on a level line, and are valid for one shape of rail motor coach, similar to that of ordinary railway carriages, which shape, consequently, has not been specially designed with a view to a reduction of aero-dynamic resistance. In the case of a more suitably designed shape, the influence of the speed on the necessary tractive force is less appreciable. If, therefore, higher speeds are to be the aim, there must be an improvement in the shape of the vehicle.

The influence of the shape of the vehicle on the increase of power will be illustrated later by means of an example.

Four-axle rail motor coach for a speed of 90 km. (56 miles) per hour.

With a view to providing a particularly intense shuttle service between two large neighbouring towns (Frankfort-on-Main and Wiesbaden), the Reichsbahn placed an order in the Spring of 1930 for three high-power rail motor coaches and three trailers. As the carrying capacity of a four-axle rail motor coach (about 80 passengers seated and 20 standing) would probably be insufficient for the number of passengers to be carried, it was necessary that the rail motor coach should be able to haul a vehicle of approximately the same carrying capacity.

As a speed of 90 km. (56 miles) per hour had to be attained, it followed that a fairly high power was necessary, and, prior to this period, there where no high-speed Diesel motors on the market. Messrs. Maybach Motorenbau, Limited, however, had designed a twelve-cylinder Diesel motor, capable of developing 410 H.P. at 1 400 revolutions per minute. This motor was selected as the most suitable for the object which it was desired to attain. Construction and testing took a considerable time, so that the first vehicle equipped with this motor has only recently begun its test runs.

The trailers were taken from new deliveries of four-axle carriages, intended chiefly for express trains and fast ordinary trains. In order to avoid the necessity of turning round at terminal stations, these trailers were also equipped with driving compartments. As the rail motor coach must also be able to run alone when required, it naturally had to have a driving compartment at each end, although, of course, this made it impossible to have vestibule gangways.

In view of the power and high speed, electric transmission of the Maffei-Schwartzkopff type was adopted. The Ward-Leonard device, with slight modifications, permits of running the principal motor group at 1 400 or at 1 100 revolutions per minute, or even at 400 revolutions when running light. The Maybach 410-H.P. motor directly drives a continuous current generator as well as an exciter dynamo. The complete motor group was installed in a bogie in which the distance between the axles is 4 100 mm. (13 ft. 5 7/16 in.) (fig. 1).

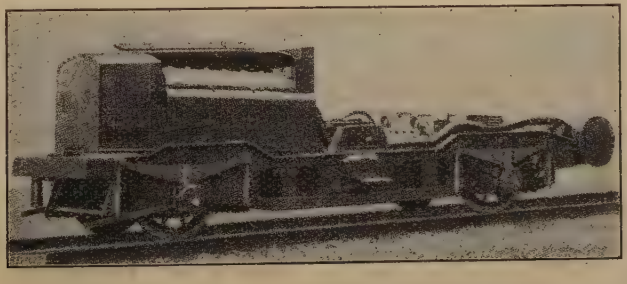

Fig. 1. — Bogie with mechanical equipment (12-cylinder Diesel motor for vehicles, made by Messrs. Maybach-Motorenbau, Ltd.) of the rail motor coach, figure 2.

It was possible to instal the generator entirely under the floor, so that no undue space was lost. In this respect this rail motor coach is superior to similar vehicles of comparable power constructed abroad. The two electric motors drive the axles of the other bogie, in which the distance between axles is 2 600 mm.

(8 ft. 6 3/8 in.). A more detailed description of the electric installation will be published elsewhere.

Fig. 2. — Eight-wheeled rail motor coach with 410-H. P. Maybach motor and electric transmission, built by the Waggonfabrik Wismar and Maybach-Motorenbau.

The rail motor coach (figure 2) has a total length over buffers of 22 130 mm. (72 ft. 7 1/4 in.), and a tare weight of 50 tons; the trailer weighs about 38 tons.

Figure 3 shows the relation between the gradient and the running speed (speed in km. per hour) for the rail motor coach: (*a*) running alone, (*b*) running with a trailer.

These vehicles are still constructed on the ordinary principles of passenger carriage construction in use up to the present. In accordance with new ideas, these vehicles are therefore too heavy. Plans for effecting a considerable reduction in weight are already under consideration for future vehicles. The weight of the rail motor coaches will be reduced to about 42 tons and that of the trailers to about 20 tons. These reductions of weight will be achieved almost entirely by modifying the constructional part of the vehicle itself, as there can be little further saving on the weight of the mechanical installation.

Rail motor coaches for secondary lines.

On secondary lines conditions are quite different. In particular, the principal limitation is in the matter of increase of speed. The maximum authorised speed is, in this case, only 50 km. (31 miles) per hour, as laid down by § 66 *e* of the « Permanent Way and Working Regulations » (B.B.O.) for double-track secondary lines laid on their own ground-work, and so far as the line installations and the vehicles themselves

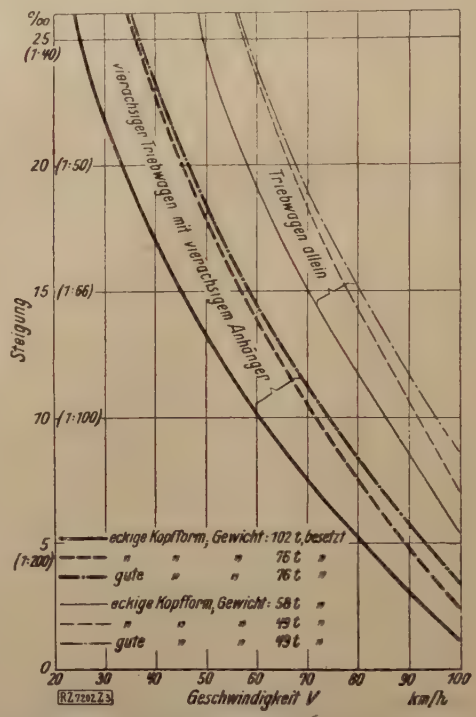

Fig. 3. — Diagram i — V for the rail motor coach, figure 2, drawn up for a power of 393 H. P. after deduction of 17 H. P. for auxiliary machines; the dotted lines show the influence of the reduction of weight in the most recent vehicles.

Explanation of German terms:

Eckige Kopfform, Gewicht... *t.*, besetzt = Angular head, weight of rail motor coach loaded, ... tons. — Gute Kopfform, Gewicht ... *t.* besetzt = Suitable shape of head, weight of rail motor coach loaded, ... tons. — Geschwindigkeit V = Speed V. — Steigung (*i*) = Gradient (*i*). — Triebwagen allein = Rail motor coach alone. — Vierachsiger Triebwagen mit vierachsigem Anhänger = Eight-wheeled rail motor coach with eight-wheeled trailer.

comply with the conditions applying to main lines. This speed may be increased to 60 km. (37.3 miles) per hour by

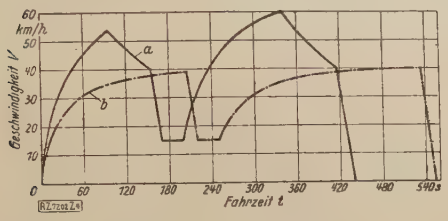

Fig. 4. — Diagrams of speeds for a line 5 km. (3.1 miles) in length, with a gradient of 1 : 115, with a slowing up zone at kilometre post 2.

a) New four-wheeled rail motor coach with 110-H. P. motor, weighing loaded 16 tons. Quick acceleration, short working periods for motor. Total time of journey = 440 seconds.

b) Old four-wheeled rail motor coach, with 75-H. P. motor, weighing loaded 24 tons. Less speedy acceleration and lower speed. Braking without previous coasting. Long working periods for motor. Appreciably longer time on journey, about 570 seconds.

Explanation of German terms:
Fahrzeit t = Time taken on journey t.
Geschwindigkeit V = Speed V.

authorisation of the Ministry of Transport. As regards secondary lines which do not fulfil these conditions, the maximum authorised speed is 35 km. (21.7 miles) per hour.

Efforts will naturally be made to secure a modification of these restrictive regulations, but as this might lead to considerable difficulties, an attempt must at least be made to get up the prescribed maximum speed as rapidly as possible and to maintain it for as long as possible. From this point of view, all the low-speed lines are particularly inconvenient. At the numerous level crossings which are not protected by barriers (3) the speed must, for example, in accordance with the « B.B.O. » § 18 (3), be reduced to 15 km. (9.3 miles) per hour. If the stopping and slowing-up points follow one another at short intervals, the whole journey becomes nothing more than a series of periods of starting and braking. It may happen, indeed, that the maximum authorised speed is not even reached if the excess of motor effort of the vehicle is unable to give the necessary acceleration (fig. 4).

Acceleration is, therefore, a factor of prime importance. On the other hand, in view of the usual speeds on secondary lines, air resistance is a negligeable factor, so that less importance need be attached to the aerodynamic form of the vehicle. Against this, however, the resistances which depend on weight — in order of importance, gradient resistance and acceleration resistance — are of prime importance.

Comparing two rail motor coaches of the same size and form, one of which weighs, for example, 10 metric tons and the other 20 tons, the lighter vehicle requires, for a gradient of 1 in 50, at a working speed of 30 km. (18.6 miles) per hour, under normal working conditions, a tractive force of 265 kgr. (585 lb.), whereas the heavier vehicle requires 490 kgr. (1 080 lb.). The motor powers, on which the consumption depends, are in the same ratio. Very similar tractive forces are necessary to obtain an acceleration of 0.20 m./s² (0.656 foot per s²) *on the level*, with the same vehicles.

This shows:
the great importance to be attached to light construction, (4) particularly for the working of secondary lines. If it is really desired to effect appreciable reductions in weight, a whole series of fundamental principles governing construction standards, workshop regulations must be left aside or appreciably al-

(3) Concerning level crossing barriers, see for example, *Reichsbahn*, vol. 7 (1931), p. 893.

(4) By « light construction » is meant « the reduced construction weight in relation to the paying floor area ».

tered and constructional technique — principles which up to the present have been accepted unquestioningly as regards the construction of railway vehicles, but which were only justified in the case of trains composed of locomotives and a number of carriages.

For example, any idea of interposing the rail motor coach in another train must be abandoned, for this use of the rail motor coach would necessitate a particularly robust construction of the frame and of the draw and buffer gear, as in the case of ordinary railway carriages. Further, it will be necessary to restrict somewhat the height of the vehicle, make the walls, flooring and ceiling much thinner, do away with intermediate partitions, and avoid as far as possible too heavy brake rigging. Thick tyres which will bear repeated re-turning must be abandoned. From the latter point of view much weight can be saved if the practice of replacing tyres more frequently can be adopted. In the future, solid axles will very often be replaced by hollow axles. In place of the standard rolled sections adopted in the construction of railway rolling stock, recourse must be had to lighter sections, of the Mannsted type, or even to the use of pressings. Further, rivetted joints, with their accompaniment of gusset plates and packing pieces, will be replaced by autogenous welding. Finally, a vehicle of such light construction cannot be expected, like an ordinary railway carriage, to last for 30 years or more.

Figure 5 shows, for purposes of illustration, a typical cross section of the side wall of a light 4-wheeled rail motor coach.

Light metal will be used with advantage for those parts which are not subjected to excessive stresses or exposed to heavy wear. It is desirable, however, to proceed with caution, and by gradual stages. Thus, for example, in the experimental train which has been running for some time on the Berlin-South line (5), the solebars, the main cross bearers, the buffer beams and buffer struts are made of steel; but the remaining parts of the frame, the body

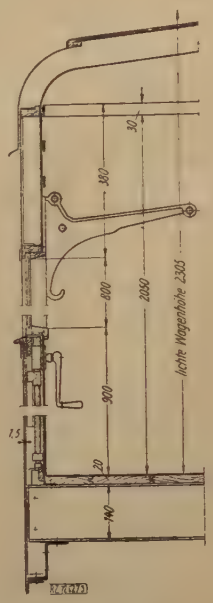

Fig. 5. — Cross-section through side of four-wheeled rail motor coach of light construction, of sheet steel.

N. B. — Lichte Wagenhöhe = Height of the body.

and roof skeletons, the internal and external linings, the compartment partitions and doors, have been made of light metal. Use has been made in some cases of *Scleron* and in others of *Lautal* alloys. The specific weight of these alloys is 2.75. The saving of weight can be seen from the following table .

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(5) Cfr. G. Wagner, Leichmetall-Stadtbahnwagen (Tramway coaches built of light metals), *Glasers Annalen*, vol. 109 (1931), p. 100.

	Old-type steel construction.	New light steel construction.	Light metal construction.
Weight of rail motor coach in metric (*English*) tons	45.5 (44.8)	38 (37.4)	35 (34.4)
Weight of trailer in metric (*English*) tons.	33.9 (33.5)	27 (26.6)	24 to 25 (23.6 to 24.6)

Compared with the old heavy steel construction, the difference is considerable; it is slight compared with the new light steel construction. To this must be added the consideration that the cost of the light alloys is very high and that the durability of these alloys has still to be ascertained. It is, therefore, desirable to determine carefully whether the economies which might be effected by the reduction of the consumption of energy in light metal vehicles are not, on the other hand absorbed by the interest and amortisation charges. Tests are in progress with a view to translating this question into figures.

Attention must be drawn to one remarkable vehicle:

The two-axle light metal rail motor coach of the Halberstadt-Blankenburg line.

This is designed specially for exceptionally heavy gradients and weighs only 10.3 t. (10.1 Engl. tons). It has been possible to reduce the weight to a certain extent by dispensing with side buffers, but the main saving in weight is derived from the use of light metal and from the meticulous calculation of each constructional element (6). The vehicle provides 26.5 m² (285.2 sq. feet) of effective floor space, without counting the space occupied by the driver's cab. It weighs only 390 kgr. per m² (80 lb. per sq. foot). In this case also, the desire to effect a saving in consumption led to an extensive use of light metal. It seems probable, however, that, for new orders, it will be the light steel construction that will be considered.

Four-wheeled rail motor coaches of the German State Railway Company (Reichsbahn).

As has been seen, light steel construction gives a reduction in weight approximating very closely to that obtained by using light metal. The Reichsbahn has therefore chosen the light steel construction for its new 4-wheeled rail motor coaches. These rail motor coaches (fig. 6) were ordered at the beginning of 1931

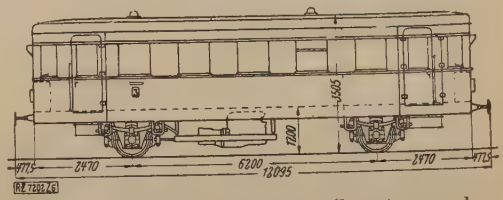


Fig. 6. — Light four-wheeled rail motor coach of the Deutsche Reichsbahn, type 1931, with 100-H. P. petrol motor.

and were at once put into service. Three of them were built by *Wumag Görlitz* and equipped with 100-H.P. *Maybach* explosion motors and *Mylius* speed gear boxes. Three others, built by the *Linke-Hoffmann-Buschwerke*, have 12-H. P. *Vomag* motors and *Triebwagenbau A. G.* gear boxes. The results of the tests have been very satisfactory.

Two rail motor coaches are being built by the *Vereinigte Westdeutsche Wagonfabriken*, with a very free application of the autogeneous welding process. They will be fitted with *Daimler-Diesel* motors,

(6) See STEINHOFF, *Verkehrstechnik*, vol. 9 (1928), p. 700.

of practically equal power (type OM 54: 100 H.P. at 1 400 r. p. m.; 120 H.P. at 1 700 r. p. m.), and will have the *Gebus* system of electric transmission. As these vehicles are intended for use on secondary lines, their maximum speed of 65 km. (40.4 miles) per hour is adequate.

The tare weight of these rail motor coaches is from 12 to 13.5 t. (11.8 to 13.3 Engl. tons). The equipment accounts for about 500 kgr. (1100 lb.). They have an effective floor space of 26.5 m² (285.2 sq. feet); there is thus a weight of only 490 kgr. per m² (100 lb. per sq. foot) as compared with 820 kgr. (168 lb. per sq. foot) in the case of the 4-wheeled rail motor coaches of the year 1925.

There is 8 H.P. per ton of vehicle weight, as against 3.75 H.P. in the case of the old rail motor coaches. The relatively high power of the motor allows of a very varied utilisation of the vehicle. When running alone, these rail motor coaches have very good acceleration on starting. On lines where there is less necessity for quick acceleration, trailers can be added. Very satisfactory speeds are also obtained on heavy gradients (fig. 4).

The arrangement of the compartments has been simplified as far as consistent with the service requirements. The 2nd class has been abandoned; on the other hand, a lavatory has been retained. The necessity for a second driving compartment is open to question. From the point of view of working, the second driving compartment is an advantage because it avoids the necessity for turning the vehicle. Consideration had also been given to the question of whether it would not be an advantage to replace the ordinary arrangement of the draw and buffer gear by a central coupling similar to that used for tramway vehicles. There is undoubtedly a saving in weight with vehicles which have central coupling, and moreover with vehicles of this type there is no risk of their being coupled to unsuitable trailers. On the other hand, vehicles without side buffers are liable to a certain amount of deterioration, due to the effect of continued impact with other vehicles, which invariably occurs. For these reasons these rail motor coaches were also provided with side buffers and with a simple screw coupling, without a safety coupling. The buffers and the coupling are of particularly light construction in view of the fact that these vehicles are not intended for use with trains. Further, if desired, it is quite easy to remove the buffers, as for example in the case of certain lines where it has been found that they are unnecessary.

Simultaneously with the purchase of these rail motor coaches, orders were placed for trailers, whose tare weight it has been possible, by reason of the absence of mechanical installations, to reduce to 10 t. (9.8 Engl. tons), or 400 kgr. per m² (82 lb. per sq. foot) of effective floor space.

The opinion is widely held that in principle it is preferable to run rail motor coaches *without* trailers, and to bring into service, in the event of an increase in traffic, a larger number of rail motor coaches. This opinion is undoubtedly sound, but it implies acceptance of the inconvenience of having to maintain a reserve of transport capacity in the form of rail motor coaches, which are more costly than trailers and not as profitably utilised, and, above all, it presupposes that it is possible to have an abundant supply of rail motor coaches available. So long as this latter condition is not realisable, it is desirable to arrange to have a reserve of trailers.

Taking into account, also, the transport of luggage and of certain express goods (e.g. milk churns), transport requirements vary greatly according to local conditions.

In order to be in a position to comply as nearly as possible with all demands of the customer, and this in the greatest

possible number of cases, some of the above-mentioned rail motor coaches have been equipped with spacious luggage compartments by sacrificing one passenger compartment of 10 seats. In case of need the seats can easily be reinstated.

A comparison of the new two-axle rail motor coaches with those of 1925 shows the following improvements: the weight per square metre has diminished by 40 %, and the motor power per vehicle-ton has increased by 113 %.

Eight-wheeled light rail motor coaches of the German State Railway Company.

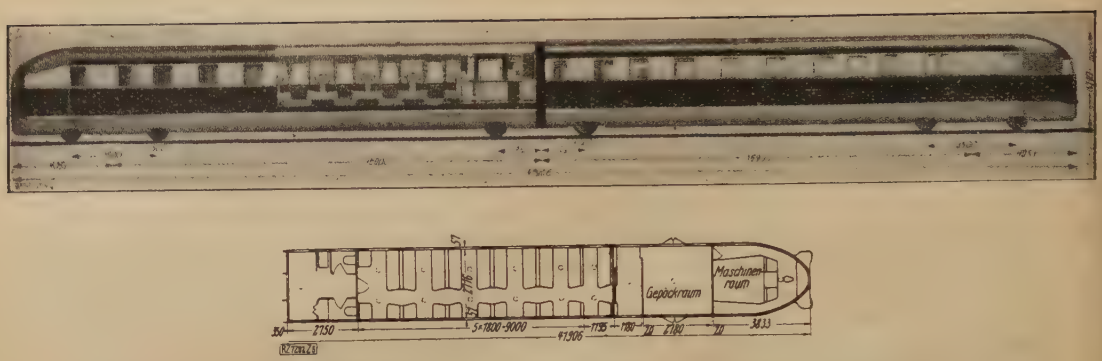
It is evident that the principles of light construction can be applied equally to larger rail motor coaches. Thus, for example, several months ago the Reichsbahn ordered five 8-wheeled rail motor coaches, provided with mechanical installation identical to that of the well-known rail motor coaches of E.V.A.-Maybach (7), which had previously been purchased. It has been possible to increase the motor power from 150 to 175 H.P. by improving the combustion chamber and using aluminium pistons. The new vehicles weigh only 690 kgr. per m^2 (141 lb. per sq. foot), as compared with 900 kgr. (184.5 lb. per sq. foot) in the case of the earlier vehicles. These improvements will make it possible to increase the speed very considerably. At the same time, eight-wheeled trailers are being built specially for use with these rail motor coaches.

Fast rail motor coaches for speeds up to 150 km. (93 miles) per hour.

In addition to road transport, the aeroplane has also now entered into competition with the railway, and in this connection efforts are being made to take the air services into account when drawing up railway time-tables. The high speed tests carried out in 1903 between Marienfelde and Zossen, and more recently the tests with propellor rail motor coaches, have shewn that, under favourable conditions, it has been possible, on the railways also, to attain speeds considerably higher than the 110 to 120 km. (68 to 75 miles) per hour hitherto generally considered to be the maximum speed.

The Reichsbahn accordingly proposes to organise, on the particularly favourable line between Berlin and Hamburg, which is free from curves and gradients, a regular fast service with a running speed of 150 km. (93 miles) per hour. The commercial speed will thus be increased to 120 km. (75 miles) per hour, instead of 90 km. (56 miles) per hour, which is the commercial speed of the fastest expresses at present. The fast rail motor coach of the Deutsche Reichsbahn intended for this service, and at present under construction (a rail motor coach which must not be confused with the « Rail Zeppelin » of *Kruckenberg)* will comprise one class (2nd) only, with seating accommodation for about 100, a buffet and a luggage compartment. The required floor space could not be got in a single eight-wheeled vehicle. The obvious solution was to have *two vehicles close coupled,* with a wide communicating gangway. Separating or altering this unit could not be considered in this case. It is evident that at this speed the external form of the vehicle plays an important part. In order to reduce air resistance to a minimum it would have been necessary to have different designs for the front and back ends of the rail motor coach, approximating as far as possible to the ideal form, namely that of a drop of water or fish. There could, however, be no question of turning round the vehicle at the terminal

(7) Cf. M. Breuer. *Glasers Annalen*, vol. 95 (1924), p. 224 and Ebel, *Organ für die Fortschritte des Eisenbahnwesens*, vol. 63 (1926), p. 127.



Figs. 7 and 8. — Fast running twelve-wheeled rail motor coach, Diesel-electric, of the Deutsche Reichsbahn, for a speed of 150 km. (93 miles) per hour. For the Diesel-dynamo group, see figure 9.

N. B. — Gepäckraum = Luggage compartment. — Maschinenraum = Engine room.

stations, and therefore it was necessary to adopt an identical shape for the two ends of the vehicle (figs. 7 and 8).

An approximate calculation of the weight of the vehicle will show that six axles would suffice. The double vehicle will thus rest on two end bogies and on one common bogie of the *Jacobs* type. In order to avoid the formation under the vehicle of disturbing air whirls, a covering of sheet metal has been fixed along the whole length of the vehicle. The radiators, which are artificially cooled, are fitted under the vehicle, so as to avoid inconvenient superstructures. As all re-entrant angles exercise an adverse influence on speed, the windows and doors have been constructed flush with the external surface, and the head lamps have been set back behind the curved ends of the vehicle. The place of the usual disc buffers has been taken by a bumper beam of appropriate shape, offering much less resistance to the air.

The most appropriate shape of vehicle, and the probable value of the aero-dynamic resistances, were ascertained by means of a model running in an aero-dynamic testing tunnel. The calculations of the necessary motive power, based on the results of these tests, showed that two internal combustion motors, of about 410 H.P. each, with electric transmission, would be adequate. It thus became a question of installing in each of the end bogies a motor unit, comprising a 410-H.P. Maybach motor with its electric generator, of the type described above in referring to the rail motor coach running between Francfort and Wiesbaden. The new Maybach motors will, however, be built without compressors. Figure 9

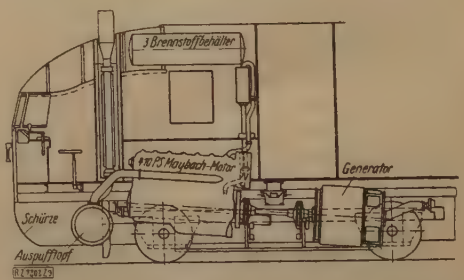


Fig. 9. — Arrangement of the Diesel dynamo group in the end bogies of the fast rail motor coach of the Deutsche Reichsbahn (figs. 7 and 8).

Explanation of German terms:

Auspufftopf = Silencer. — 3 Brennstoffbehälter = 3 fuel tanks. — Generator = Generator. — 410 PS Maybach Motor = 410-H. P. Maybach engine. — Schürze = Sheet metal covering.

shows the installation of the motor mechanism in the bogie and the end of the vehicle. The electric transmission is of the « Gebus » type (8).

The electric propulsion motors are installed in the « Jacobs » central bogie. This bogie is more heavily loaded than the two others and has a suitable adhesive weight. The inverse arrangement (also taken into consideration) consisted in installing the two generators in the middle bogie and the electric motors in the end bogies; but this arrangement would have resulted in an inconvenient break of continuity of floor space in the passenger compartment. The electric propulsion motors each weigh 2 500 kgr. (5 500 lb.) and rest by means of axle caps on the motor axle, which they drive through simple cylindrical gearing. The non-suspended weight of the motor axles is, it is true, somewhat high; already, however, certain locomotives are running under less favourable conditions without any inconvenience being experienced. It was, therefore, decided to dispense with the complete suspension of the propulsion motors, in view of the simplification and of the lower initial capital outlay.

A more detailed description of this rail motor coach would take up too much space here and must be reserved for a subsequent article. The firms *Wumag*, of Görlitz, *Siemens-Schuckertwerke*, *Maybach-Motorenbau* and *Knorr-Bremse* are participating in the construction of the vehicle, in constant collaboration with the Central Administration of the Reichsbahn (Reichsbahn Zentralamt für Maschinenbau). The fast rail motor coach will be put into service in the Spring of 1932, and thereafter the time taken on the journey between Hamburg and Berlin will be reduced to 2 hours 20 minutes (the fastest train at present, the F.D. 23, takes about one hour longer).

(8) O. Judtmann, *Verkehrstechnik*, vol. 9 (1928), p. 473, and *Spoor en Tramwegen*, vol. 4 (1931), p. 173.

Braking at high speeds.

Great difficulties presented themselves when considering the question of braking at these high speeds. The kinetic energy A of the vehicle, which depends on the square of the speed V, must be absorbed by the effect of the retardation pressure W_b in the shortest possible stopping distance, s, so that $\frac{M V^2}{2} = A = W_b s$ Assuming that it is possible to maintain W_b invariable throughout the braking, it would follow, in this case, from the above equation, thas s increases with the square of the speed. It is found, further, that the lengths of the stopping distances are still more unfavourable when W_b diminishes with the increase of speed. This inconvenience is peculiar to the railway rolling stock brake, in which the cast iron brake shoes act on steel tyres (9).

Distinctly more favourable braking conditions are obtained with linings with an asbestos base (Jurid), as has been proved in automobile construction. These linings, however, do not last sufficiently long unless they are not subjected to too high unitary pressures and unless they act on « polished » surfaces. It is for this reason that special brake drums have been bolted on to the webs of the wheels of the fast rail motor coach, the brake segments with their Jurid linings, acting on the outside of the wheel drums.

In order to render unnecessary heavy and cumbersome brake rigging, the brake has been sub-divided and there are a large number of small brake cylinders controlled in the ordinary way. With a view to simplification, however, the motor shafts are not braked. As a

(9) See special issue of *Glasers Annalen*, 1 July 1927, p. 138.

result of the suppression of the brake pull rods, it has also been necessary to modify the control of the hand-brake. The hand-brake wheel now acts, through a spring, on a simple oil pump. The spring maintains the oil pressure, even when there is slight leakage. Small cylinders of oil under pressure furnish the necessary braking energy.

The compressed air brake equipment is manufactured by the *Knorr-Bremse A. G.* and the oil pressure brake by Messrs. *Tewes* of Frankfort - on - Main. With the aid of these brakes it will be possible, with complete safety, to stop the fast rail motor coach, running at its maximum speed of 150 km. (93 miles) per hour, within a distance of 1 100 m. (3 600 feet). The adhesion between wheel and rail is here utilised to the extreme limit.

In order still further to reduce the stopping distance, it would be necessary to have recourse to additional braking power acting without the aid of adhesion between wheel and rail, unless it were possible to increase the coefficient of adhesion in a manner compatible with safety. Electro-magnetic rail brakes which might have been thought of at first could not have provided a solution, as it was realised that they were inapplicable in view of the high speed. Having regard to the stage of technical development at that time, it was impossible to obtain a shorter stopping distance and still observe the present regulation distances between distant and home signals.

It was thus necessary to increase the distance between distant and home signals to suit the stopping distance above mentioned. At the present time, work is in progress on the Hamburg-Berlin line for removing the distant signals to a distances of 1 200 m. (3 930 feet) before the home signals, thus reserving a certain margin against the eventuality of further increases of speed. The increased distance of the distant signal location obviously renders signal control more complex and, moreover, is less suitable for trains running at lower speeds.

It follows from the above considerations that an increase of running speed beyond the present speed of fast trains, implicitly pre-supposes very serious modifications in the permanent way equipment. This becomes more obvious when it is remembered that in conformity with the B.B.O. § 66, curves of 1 200 m. (60 chains) radius must not be taken at a speed exceeding 120 km. (75 miles) per hour, and that the super-elevation of the track has been calculated and fixed up to the present for this maximum speed. If, then, it is desired to run considerable distances, without risk, at speeds of 150 km. (93 miles) per hour or above, it will be necessary to modify the super-elevation or the radii of curves, or both, which will obviously entail considerable expense. It is probable that there are very few lines which, without modification, can be covered at these high speeds.

Reference may be made, in passing, to the difficulty of introducing such fast runs into a time-table which must also comprise ordinary fast trains, slow trains and goods trains [10].

The propeller-rail-motor coach.

A fortiori, the above considerations apply when still higher speeds are adopted, as for example in the case of the *Kruckenberg* propeller-rail-motor coach [11]. The tests, in the course of which a maximum speed of 230 km.

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[10] Cf. FLACHS, Verwendung von Schnelltriebwagen (Operation of fast rail motor coaches), *Verkehrstechnische Woche*, vol. 25 (1931), p. 644.

[11] For further details, see F. KRUCKENBERG and C. STEDEFELD, Der GVT-Propellertriebwagen (The propeller-driven rail car), *Verkerstechnische Woche*, vol. 24 (1930), p. 679.

(143 miles) per hour has been reached, have only been made possible by the application of special measures, such as the suppression of block sections doubling of block sections for other trains, and increased precautions at level-crossings. These difficulties can only be overcome if the fast traffic is localised on new lines, the construction of which, for the time being at least, is likely to run up against the problem of the initial cost of construction.

It is none the less of great interest to consider the technical means whereby the attaining of these high speeds has been made possible. These are, in order of importance :

1. The most appropriate vehicle outline.

2. The lowest possible weight.

3. A method of propulsion specially adapted to high speeds.

The propeller-rail-motor coach has only one driving compartment. In front it is rounded off, and it tapers off at the rear end. Consequently, it can only develop its maximum speed when running in one direction. To permit of running in the reverse direction, it has been necessary to exchange the forward-running propeller for a propeller acting in the opposite direction, while for shunting movements use has been made of an auxiliary (electric) means of propulsion, driving one of the axles of the rail motor coach. [$V \leqslant 30$ km. (18.6 miles) per hour]. In order not to complicate the problem still further, the idea of equally fast running in both directions has been abandoned.

With a view to reducing the weight, the body frame has been made of tubing, while the side walls, which are incurvated, are made of light metal sheets and of an impregnated fabric; but, above all, electric transmission has been avoided. The passenger compartment has 24 seats. The effective floor space is 41.6 m^2 (447 sq. feet) and the total tare weight of the rail motor coach is about 19.5 t. (19.2 Engl. tons) so that the tare is 450 kgr. per m^2 (92.2 lb. per sq. foot) of effective floor space.

From the point of view of simplicity, the system of propeller drive is by far the best, as the propeller shaft is driven directly by the combustion motor.

Numerous causes of defects disappear through the fact that the reactions are not transmitted by a succession of shocks. On starting, however, the functioning of the propeller is accompanied by considerable waste of energy, and even at speeds between 100 and 150 km. (62 and 93 miles) per hour, the output is not economic; it only becomes so at higher speeds. It will not be possible, therefore, to determine the actual position in this respect until comparative tests can be carried out with other fast rail motor coaches. It would be a great advantage if both propulsion and braking could be rendered independent of adhesion. We have remarked, it will be remembered, that a supplementary retardation force, independent of the wheels, was still required to diminish stopping distances. A reversible movement propeller could furnish this supplementary retardation force, but undoubtedly this question presents considerable technical difficulties. The rail specialist must certainly have been particularly struck by the fact that the *Kruckenberg* propeller rail motor coach has only two axles, placed exceptionally wide apart (19.60 m. = 64 ft. 4 in.). The absence of bogies is justified on the one hand by the reduction in the total weight, and on the other by the fact that a weight is obtained per axle sufficient to ensure safe running on the track. This latter essential is in any case assured with a weight per axle of 5 tons, which might be obtained by having two bogies (compare, for example, the Michelin rail motor car). The fact of having only two axles entails the following disadvan-

tages : in order to ensure the guiding of the rail motor coach on curves of small radius — which the safe negotiation of points renders unavoidable — it is necessary that the axles should be able to take a radial position. Here, however, the radial setting of the axle, is not automatic as in the case of bogie vehicles, but is obtained artificially by the driver, by means of a controlling device. Although very ingenious, the operation of this device demands much caution. It cannot be used at high speeds and, even at 45 km. (28 miles) per hour, at which speed points may be run over, it requires much experience and attention to operate the controlling device efficiently.

Under these conditions the system of construction with two axles is not to be recommended for the object which it is desired to attain. Further, it is desirable to await the improvements which will shortly be effected in the propeller-driven rail motor coach (12).

Finally, particular attention must be drawn to

The recently introduced pneumatic-tyre rail-motor coaches

or, in other words, to the *Michelin* (13) Company's rail motor cars (« autorail »). Michelin is the first to succeed in applying pneumatic tyres to railway vehicles in a manner which ensures safe running. The plate disc wheel (fig. 10) has a flange which projects sufficiently beyond the tyre to ensure guiding on the rails. On the other hand, the tyre is carried on a detachable rim. A supporting ring fixed inside the inner air tube limits the flattening of the tyre to about 10 mm. (3/8 inch). As a result of the narrowness of the tread, the carrying capacity of the tyre is limited to 700 kgr. (1 440 lb.). Particularly light construction is therefore an absolute necessity. It is true that the fulfilment of this essential condition is greatly facilitated by the fact that the tyre in itself constitutes an absolutely elastic intermediary.

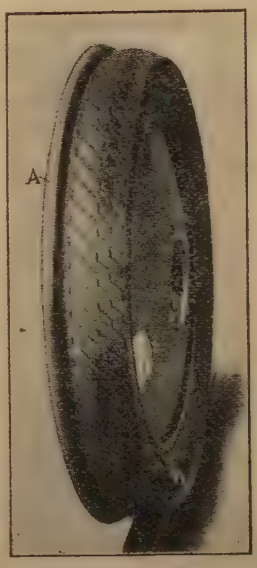

Fig. 10. — Wheel with pneumatic tyre and sheet metal flange for rail autocar, « Michelin » type.

Not only does the tyre give silent running, but it also gives greater adhesion than the steel tyre. It is thus possible considerably to augment the tractive effort at the periphery and, above all, to reduce to one-third the stopping distance required with steel tyres. Even during rain it seems that the adhesion of the pneumatic tyres is only slightly reduced, as the first wheel clears the water from the rail so that the following

(12) According to recent press informations, Kruckenberg has adopted bogies in the design of a new coach and appears to have given up the propeller drive.

(13) For more detailed description, see *Génie Civil*, vol 99 (1931), p. 112; *Zeitschrift des V. D. I.*, vol. 74 (1931), p. 1086.

See also *Bulletin of the Railway Congress*, January 1932 number, p. 58.

wheels run over a rail which is practically dry.

As has already been remarked, rapid starting and efficient braking are of prime importance for the working of secondary lines. If, for example, it is possible, from full speed, to stop a vehicle within a distance of 100 metres (328 feet), there is scarcely any further need for level crossing staff, any more than in the case of cross roads. As, with the autorail, the mass in motion is small, it is perhaps possible to simplify still further the working of secondary lines by discarding the use of signals and block sections and relying on visual driving, provided, of course, that the line is not used by other trains, at least during a given period. In such a case, goods traffic, in so far as it could not be dealt with by the autorail, would have to run only during the night.

We must wait and see to what extent the future will witness the realisation of this pleasant perspective. From the point of view of economic results, it will be important to ascertain the life of the pneumatic tyre. One disadvantage is the small load which these tyres can carry. Even with the extremely light type of construction adopted by Michelin, the transport of only 24 passengers requires no less than ten wheels. Michelin has not devoted his attention to the problem of using trailers with the autorail, his point of view being that as traffic increases it will be sufficient to multiply the number of autorails running on the line (14).

The success of the *Michelin* autorails will depend not only on the life of the pneumatic tyres, but also on the possibility of increasing their carrying capacity.

Henschel and Sohn's motor bus.

Henschel also has endeavoured to reduce the weight of the non-suspended mass by interposing an elastic intermediary in the wheel centre. Such a rail motor bus (fig. 11), equipped with

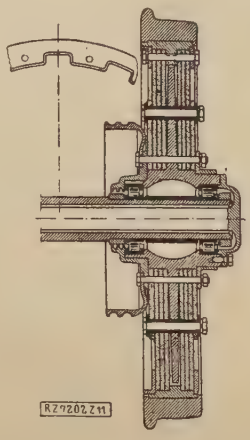

Fig. 11. — Vehicle wheel with elastic rubber disc between the rim and the wheel boss, for rail motor bus, Henschel & Sohn type.

wheels with rubber disc centres, and the mechanical equipment of which (for purposes of mass production) is almost exactly similar to that of the larger road motor coaches, attracted considerable attention at the 1930 automobile show (15). The first vehicle had only one driving compartment and must consequently be turned round at terminal stations. One of them is in service on the private line between Grifte and Gudensberg. Two new rail motor buses slightly modified, are under construction for the Reichsbahn. They will have two driving compartments and an entrance in the middle. Their weight will be approximately the same as that of the 4-wheel rail motor coaches described above.

(14) Cf. what is said on this subject on page 1130.

(15) See *Organ für die Fortschritte des Eisenbahnwesens*, vol. 86 (1931), p. 181; *V.D.I. Nachrichten*, 1931, No. 8.

Rail motor goods vans.

The transport of parcels has also been considerably accelerated during the last few years. In many places parcels trains, which, because of their numerous stops, take a long time on the journey, have been replaced to great advantage by light goods trains (Leig) (16). These trains are drawn by a passenger train locomotive and consist either of a four-wheeled van and a very large covered wagon, or of two wagons of the latter kind connected by means of vestibule gangways, thus affording a combined loading space of great capacity, with two doors on each side.

In order to solve this problem, the Deutsche Reichsbahn has acquired three rail motor coaches for goods. These first eight-wheeled rail motor goods coaches, built by the Waggonfabrik Wismar, have a maximum speed of 65 km. (40.4 miles) per hour (fig. 12).

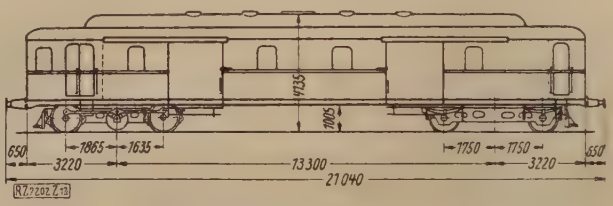

Fig. 12. — Rail motor van of the Deutsche Reichsbahn. with 150-H. P. Maybach motor.

They have two bogies, one of which carries the well-known Maybach mechanical equipment (150-H.P. motor with mechanical transmission, jack shaft and coupling rods).

The luggage compartment has 38 square metres (409 sq. feet) of effective floor space. It was scarcely possible to increase still further the floor space in an eight-wheeled vehicle. A double vehicle would have been too expensive for the purpose of a preliminary trial.

The loading capacity is 15 000 kgr. (33 000 lb.). From the operating point of view, the goods rail motor van, when compared with the light goods train, has the advantage of being immediately ready for running in either direction and, further, of being more easily brought up to the desired loading spot on short dead-end lines. However, in the present situation it is hardly possible to run these vehicles under more economic conditions than the « Leig » trains, composed of available wagons and surplus locomotives. It is indeed remarkable that the running costs of these rail motor vans are not higher.

Appreciable economies, relatively to steam traction, cannot be effected here until it becomes possible to obtain the goods rail motor coaches at a lower cost, which will be possible when orders can be placed for a larger number at a time, and when there will no longer be any spare locomotives available. When new orders are to be placed, it will be desirable to aim at a larger loading space and an increase in speed to 80 km. (50 miles) per hour.

* * *

The new types of rail motor coaches described above will be tested out during the present year. From the point of

(16) See H. Nordmann, *Zeitschrift des V. D. I.*, vol. 75 (1931), p. 1238.

view of the construction of new units, it is particularly satisfactory to note that at the present time, there is quite a considerable selection of high-speed Diesel motors on the market (17).

As several of these types of motors have only recently been perfected, they could not be cited among the rail motor coaches described above, the construction of which was put in hand more than a year ago. New prospects are opened for railway working, more particularly thanks to efforts to increase the possibility of motor supercharging, for example by the application of the process of superfeeding, with the object of dispensing with the complex speed gear boxes or with electric transmission, which is so heavy and costly, or, at any rate, of being able to simplify these transmissions considerably.

It is most desirable that the permanent way and operating regulations, which are unduly restrictive as regards the working of secondary lines, should be adapted at an early date to suit the new requirements and to fit the characteristics of light rail motor coaches.

(17) See special issue « Dieselmaschinen V » of the *Zeitschrift des V. D. I.*, Berlin, 1931.

Cf. also W. Laudahn, *Glasers Annalen*, vol. 108 (1931), p. 163.

[621 .132 3. (.44)]

4-8-2 type locomotive, No. 241 001, for fast heavy trains, of the French Est Railway.

(*Revue Générale des Chemins de fer*, October 1931)

To meet the growing post-war passenger traffic requirements, the French Est Railway Company has found itself obliged to increase both the load and the average speed of its fast trains. By 1924 it had become evident that the power of the 4-6-0 type locomotive with coupled wheels 2.09 m. (6 ft. 10 1/4 in.) in diameter and the 4-6-2 type with 1.94 m. (6 ft. 4 13/32 in.) wheels, used to haul these trains, would be insufficient in the near future, especially on the heavy line between Paris and Belfort, as soon as the use of metal coaches became general, and the Company decided to put in hand the design of a much more powerful locomotive. The maximum permissible axle load being 18.5 tons on the lines of the Company, the new locomotive was of the 4-8-2 type.

The whole of the drawings were prepared by the Rolling Stock Designs Office and one engine, No 241 001 was built in the Railway Company's Workshops at Epernay between July 1924 and January 1925.

This locomotive has four pairs of coupled wheels with a bogie at the leading end and a bissel truck at the trailing end. Its leading dimensions are given in the diagram, figure 1.

The large diameter of the wheels [1.95 m. (6 ft. 4 25/32 in.)] should be noted, as this is a size which has never yet been used so far on any European locomotive having four pairs of coupled wheels.

In spite of its large rigid wheel base, 6.15 m. (20 ft. 2 in.), and the absence of any lateral side play in the axle boxes, this locomotive easily runs round a curve of 100 m. (5 chains) diameter [gauge widened to 1.460 m. (4 ft. 9 15/32 in.)], by means of a lateral displacement of $\pm$ 125 mm. (5 inches) for the bogie, and $\pm$ 150 mm. (6 inches) for the carrying pair of wheels. These movements are controlled by check springs with considerable initial tension.

The locomotive 241 001 is a compound engine with four cylinders; two high-pressure cylinders on the outside, driving the second pair of coupled wheels, and to low-pressure cylinders inside, driving the first coupled pair.

The motion of the Walschaerts type with piston valves is noteworthy by the long valve travel, even at early cut-off. This arrangement results in very large passages and consequently reduces the wiredrawing of the steam during admission and especially at exhaust, and makes it possible to appreciably reduce one of the drawbacks of the piston valve gear.

The rods and certain parts of the valve motion have been made from special chrome-nickel steel in order to reduce to the minimum their weight. This reduction of weight has the double advantage of improving the balancing, necessarily imperfect, of the reciprocating parts and of reducing the unsprung weight.

The boiler of engine 241 001 is pressed at 17 Hpz (17.34 kgr per cm^2 or 246.6 lb. per sq. inch); this pressure will however be raised to 20 Hpz (20.4 kgr. per

cm² = 290 lb. per sq. inch) on the 40 locomotives of the same type now under construction in the Fives-Lille Company's Works and in those of the Société Française de Constructions Mécaniques.

The firebox is of the Belpaire type with flat crown. The square box with wide grate is extended forward by a combustion chamber which appreciably increases the direct heating surface, — the most active as regards evaporation — and assures a more complete combustion of the gases before they enter the tubes. The brick arch has not been built up of bricks in the ordinary way : the refractory bricks which form it rest on three water tubes expanded in the back and front plates of the copper box ; these tubes assist in addition the circulation of water between the front and back of the firebox whilst at the same time increasing the direct heating surface.

The superheater is of the DM type at the present time fitted on all modern locomotives of the French Est Railway. The elements, 30 in number, are placed inside the 130/138 mm. (5 1/8 in.-5 7/16 in.) smoke tubes ; the « flow » circuit is formed by four flattened tubes mounted in parallel, and the « return » circuit by one single cylindrical tube. This arrangement has the following advantages : rational circulation of the steam — reduced loss of pressure — maximum of superheater surface for a minimum space required by the smoke tube.

With this superheater on engine 241 001, it is usual to obtain temperatures varying from 350 to 375°C (662 to 707°F.) even reaching 400° C. (752° F.) when the engine is forced.

A steam blower for cleaning the tubes is fitted on the back plate of the firebox ; by it the tubes can be cleaned during running.

The engine No. 241 001 is fitted with the « Kylchap » fixed blast pipe.

The back part of the grate is built up with moveable bars wich can be operated from the driver's cab by a lever. This arrangement known as a shaking grate, makes it possible to clean the fire whilst running.

The boiler is usually fed by a Davies and Metcalfe exhaust steam injector (1), a live steam injector of the non lifting type being used in addition as reserve.

The regulator consists of a single seated valve balanced by the preliminary opening of a small pilot valve. The control is very smooth, and the opening very progressive.

The lubrication is assured by a « mano-lubricator » ; the distribution is done by means of a distributor with visible outlets placed in the cab. An arrangement for admitting saturated steam at each outlet facilitates the flow of the oil through the long pipes from the distributor to the points to be lubricated and assures a better distribution of the oil in the cylinders and steam chests.

The lubricating pipes end at the following points :

On the top centre line of the high pressure valves ;

One above each of the two pistons heads of the same valve ;

Centre of the top centre line of the high pressure cylinders ;

High pressure cylinder of the air pump.

At each of these delivery points there is a connection of the low-pressure type, which is drilled with a capillary hole protected by a gauze cover ; this connection has the effect of causing a considerable reduction of pressure and of regularising the quantity of oil fed, both when the regulator is open as when it is closed.

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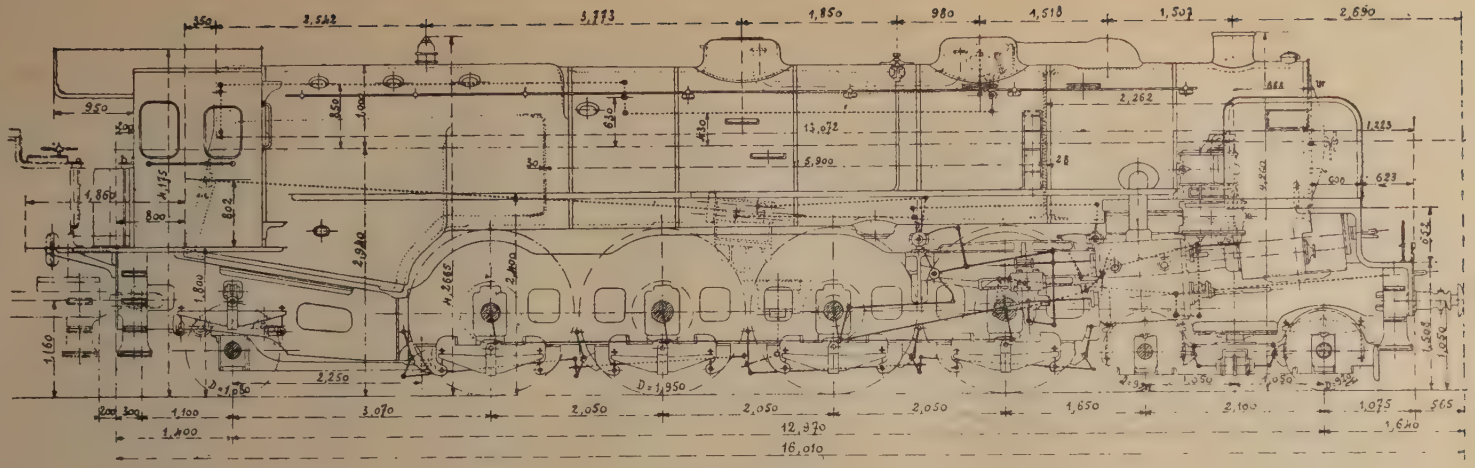
(1) On the locomotives actually under construction, it has been found necessary to take the steam for the Davies & Metcalfe exhaust injector from the intermediate reservoir, and not from the exhaust, on account of the higher pressure (20.4 kgr. = 290 lb. per sq. inch) of these locomotives.



LEADING DIMENSIONS.

Grate.

Length measured on the slope	2.395 m. (7 ft. 10 9/32 in.).
Width	1.850 m. (6 ft. 13/16 in.).
Area	4.43 m² (47.68 sq. ft.).

Tubes.

	Flue tubes.	Smooth tubes.
Number	30	130
Diameters	130/138 mm. (5 1/8—5 7/16 in.)	50/55 mm. (1 31/32 — 2 11/64 in.).
Length between tube plates		5.900 m. (19 ft. 4 9/32 in.).

Heating surface.

Of the firebox (calculated above the grate).	23.91 m² (257.36 sq. ft.).
Of tubes (developed interior surface)	193.70 m² (2084.98 sq. ft.).
Total	217.61 m² (2342.35 sq. ft.).

Boiler.

Average diameter of the barrel	1.800 m. (5 ft. 10 7/8 in.).
Interior volume of the boiler	15.110 m³ (533.60 cu. ft.).
Volume of water with 0.100 m. (3 15/16 inches) of water above firebox top at the forward end	10.460 m³ (369.39 cu. ft.).
Volume of steam with 0.100 m. (3 15/16 inches) of water above firebox top at forward end	4.650 m³ (164.21 cu. ft.).
Pressure	17.34 kgr./cm² (246.6 lb. per sq. inch).

Superheater elements.

Number	30
Diameter	31/38 mm. (1 7/32 — 1 1/2 in.).
Steam passage	0.022643 m² (0.2437 sq. foot).
Average surface of the elements	92.57 m² (996.42 sq. ft.).

Wheels and axles.

Distance between the inside of the tyres	
Bogie	1.358 m. (4 ft. 5 15/32 in.).
Coupled wheels	1.363 m. (4 ft. 5 43/64 in.).
Trailing truck.	1.360 m. (4 ft. 5 35/64 in.).

Tyres.

	Thickness *
Bogie wheels	37.5 mm. (1.476 in.).
L. P. driving wheels	20.2 mm. (0.795 in.).
H. P. driving wheels	25.7 mm. (1.012 in.).
Coupled wheels, leading pair (3rd)	25.7 mm. (1.012 in.).
Coupled wheels, trailing pair	31 mm. (1.220 in.).
Trailing truck	32.5 mm. (1.279 in.).

Bogie. Side movement ± 0.125 m. (5 inches).

Trailing truck. Side movement ± 0.150 m. (6 inches).

		High-pressure.	Low pressure.
Motion.	Diameter of cylinders	0.450 m. (17 11 16 in.).	0.660 m. (26 in.).
	Stroke of pistons	0.720 m. (28 3 8 in.).	
	Inclination of cylinders relatively to the horizontal	1 in 29	1 in 11
	Length of driving rods	2.300 m. (7 ft. 6 35/64 in.).	2.100 m. (6 ft. 10 43/64 in.).
	Stroke of coupling cranks	0.360 m. (14 3/16 in.).	
Valve motion.	Radius of eccentries	0.200 m. (7 7/8 in.).	0.110 m. (4 11/32 in.).
	Maximum displacement of the slide valves from their middle position. Forward gear (Forward)	0.0945 m. (3.76 in.).	0.0940 m. (3.70 in.).
	Forward gear (Back)	0.0985 m. (3.88 in.).	0.0975 m. (3.84 in.).
	Reverse gear (Forward)	0.0695 m. (2.74 in.).	0.070 m. (2.76 in.).
	Reverse gear (Back)	0.0705 m. (2.78 in.).	0.080 m. (3.15 in.).
	Diameter of piston valves	0.250 m. (9 7/8 in.).	0.310 m. (12 3/16 in.).
	Steam lap. Forward	0.0365 m. (1.44 in.).	0.037 m. (1.46 in.).
	Steam lap. Back	0.0365 m. (1.44 in.).	0.037 m. (1.46 in.).
	Exhaust lap. Forward	0	0.010 m. (0.394 in.).
	Exhaust lap. Back	0	−0.010 m. (0.394 in.).

Weight.

Weight empty	105 120 kgr. (231 750 lb.).
Weight loaded: with 0.100 m. (4 inches) of water above firebox top, 600 kgr. (1.323 lb.) of coal on grate and 100 kgr. (220 lb.)* of sand	114 710 kgr. (252 890 lb.).
Adhesive weight	74 890 kgr. (165 100 lb.).

* The thickness of the tyre has been taken at 10 mm. (25 64 inch) below the tread circle.

Fig. 1.

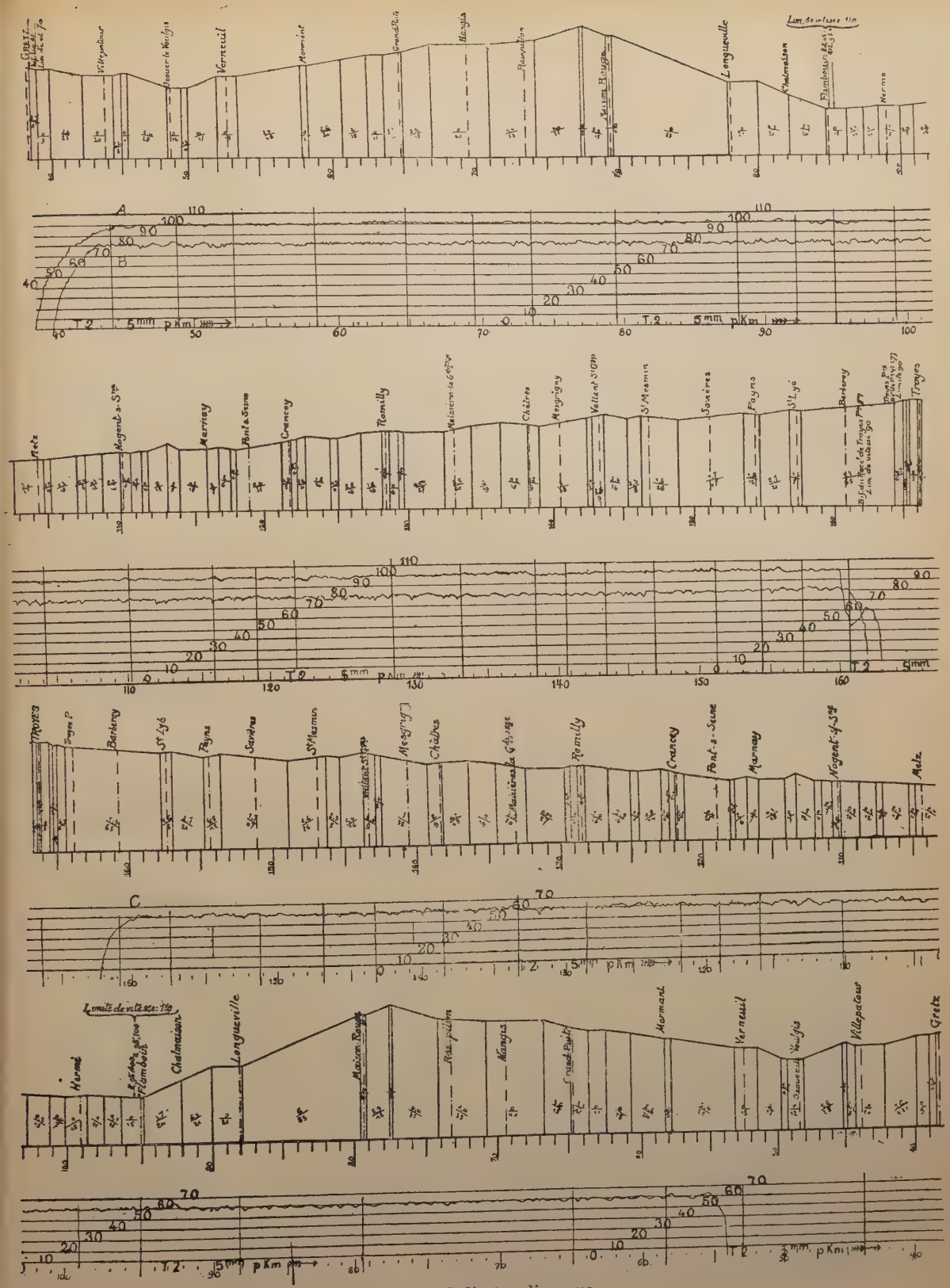


Fig. 2. — Indicator diagrams.

Explanation of figure 2 :

A. — Test run No. 159 on 16/3/1929. Speed 100 km. (62 miles — 45 %-70 % cut-off.
B. — Test run No. 161 on 18/3/1929. Speed 80 km. (50 miles — 40 %-70 % cut-off.
C. — Test run No. 162 on 18/3/1929. Speed 60 km. (37.3 miles — 55 %-75 % cut-off.

In order to avoid smoke beating down on the boiler, the locomotive is fitted at the front end with two vertical plates placed on each side of the smoke box, parallel to the longitudinal axis of the engine.

These lateral plates have the effect of creating a current of air which opposes the production of any vacuum on the cylindrical barrel of the boiler, on the side opposite to the wind. This depression, when allowed to occur, draws and holds the steam and smoke emitted by the locomotive at a place where it considerably interferes with visibility.

The M system drawgear between the locomotive and tender is of a new type; it does not include any spring and consists of a hollow pin 180 mm. (7 3/32 inches) in diameter, held in the back drag plate of the engine. A spherical union free to slide along this pin is held in a cap secured to the tender drag box. This coupling provides for vertical differences of level and in addition the movement of the tender relatively to the engine. It has in addition the great advantage that there is in the cab one platform only, that of the locomotive, which extends under the shovelling plate of the tender, so that the men are not on as it were two platforms with relative movements of changing direction and of great magnitude as on the old engines.

The comfort of the men has been appreciably increased in this way. The M type coupling at the present time has been fitted to more than 250 locomotives of the French Est Railway, an enables the tenders coupled to these engines to be interchanged.

The locomotive is fitted with the Westinghouse compressed air brake with the Westinghouse bi-compound pump.

The speed recorder is of the Flaman type ; it is fitted with an arrangement registering the position of the signals at which ramps are fitted ; this arrangement is in addition combined with an audible signal which calls attention to signals at danger.

So that the driver should not rely as regards the signals, solely upon the indication of an automatic apparatus which might fail, the Flaman is also fitted with an « alert » device which the driver has to operate as soon as he perceives a signal at danger, so as to record on the roll that he saw the signal before his attention was called by the alarm.

The locomotive 241 001, which left the Epernay Works in January 1925, was as soon as it had been run in, put to work hauling heavy fast trains. It was carefully watched in service so that it was possible to improve very quickly the behaviour of certain parts ; substitution of hard bronze for case hardened heat treated steel for the slides of the valve links, increase of the pressure with which the driving and coupled wheels were pressed onto the axles, better protection of the low pressure axle against side shocks, etc...

During the year 1928 more important alterations having been considered — in particular the increase of the diameter of the low pressure cylinders, which originally were only 610 mm. (24 in.), the alteration of the lay-out of the steam passages, in order to facilitate the flow of steam, and the application of a Davies & Metcalfe injector — it was decided that comparative tests should take place before and after these alterations, in order to decide the effect these had upon the efficiency of the locomotive.

Comparative trials.

These comparative trials were carried out by a new method, which has been

Particulars of the engine during each test.

	E. Cz No. 1	E. Cz No. 5.	E. Cz No. 5 *bis*.	E. Cz No. 5 *ter*.
Number of kilometres run by the locomotive after leaving the workshops or after general repairs at the moment of the trial.	105 000 km. (65 250 miles).	2 000 km. (1 243 miles).	28 500 km. (17 710 miles).	75 000 km. (46 600 miles).
Boiler pressure	16.32 kgr. (246.6 lb.).	17.34 kgr. (290 lb.).	17.34 kgr. (290 lb.).	17.34 kgr. (290 lb.).
Diameter of low pressure cylinders. .	610 mm. (24 in.).	660 mm. (26 in.). With improved steam passages.		660 mm. (26 in.).
Type of blast pipe top	Nord.	Nord,	P. L. M.	Kylchap,
Area of the exhaust passage	varying from 1.485 to 2.637 dm² (23 to 40.1 sq. in.).	varying from 1.27 to 2.20 dm² (19.7 to 34 sq. in.).	varying from 1.15 to 1.68 dm² (17.8 to 26 sq. in.).	fixed, first of 1.78 dm² (27.6 sq. in.), then of 1.98 dm² (30.7 sq. in.).
Type of injectors.	1 II.Z.C.V. of 7.5 mm. (2.95 in.) and 1 Z.C.V. of 10 mm. (3.94 in.), live steam.	1 Z. C. V. of 10 mm. (3.94 in.), live steam. 1 Davies and Metcalfe, exhaust steam.		
Exhaust lap for high pressure cylinders.	— 3 mm. (— 0.118 in.).	0	0	0
Exhaust lap for the low pressure cylinders.	— 3 mm. (— 0.118 in.).	—10 mm. (—0.394 in.).	—10 mm. (—0.394 in.).	—10 mm. (—0.394 in.).

used for the last three years on the Est System, and by which it is possible to obtain much more precise results than those given by previous methods used in similar tests.

The principle of this method is the following :

Each test is carried out under running conditions fixed beforehand and kept unchanged during the whole test. In particular the speed is fixed, the cut-off to the cylinders, and the exhaust opening when the blast pipe top is variable, so that the pressure at the boiler being kept quite constant during the whole test the indicated power remains the same. To carry, out on the line, tests under these conditions — which are exactly those of laboratory tests — a second locomotive is used, the role of which is to maintain during the whole period of the test, the speed of the train at a determined value, and as constant as possible ; this result is obtained by a suitable regulation of the braking effort developed by using the engine as an air compressor (1).

This method is shown very clearly by the indicator diagrams reproduced below the profile of the Gretz-Troyes test section 125 km. (77.7 miles) long (fig. 2). It will be seen that this method does away in particular with the influence of the profile of the line.

Four series of tests were carried out with engine No. 241 001. The first series took place in October 1928 after the engine had been put in good working order but with the original cylinders (test E Cz No. 1). The second series were commenced in March 1929 (E Cz No. 5) after

(1) The use of a second locomotive to regulate the speed was first suggested by Professor Czeczott, Chief Test Engineer of the Polish State Railways. He used this second locomotive, however, to give an additional tractive effort. The German Railways perfected his method by using the regulating locomotive to give a varying resistance.

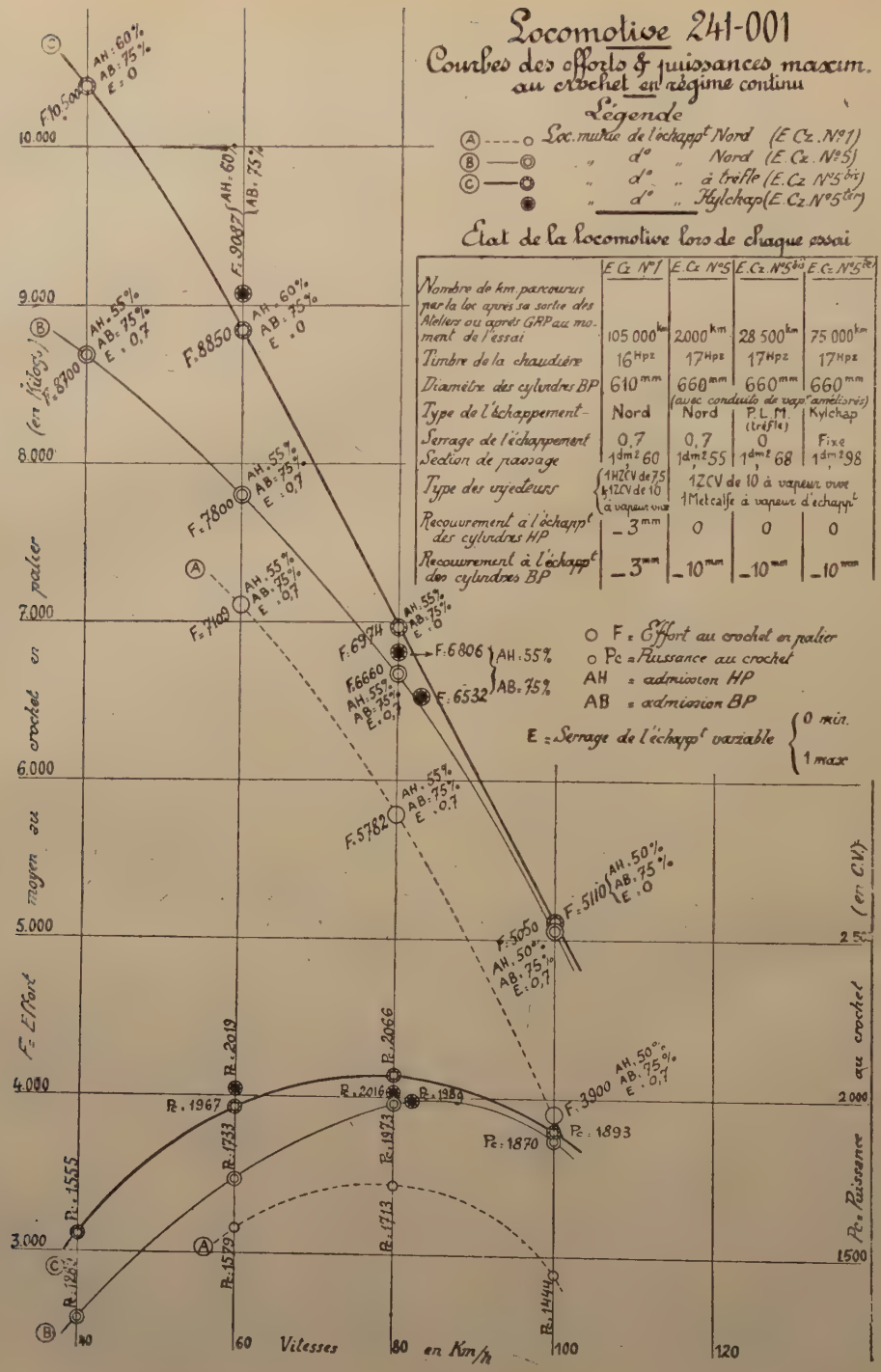

Locomotive 241-001
Courbes des efforts & puissances maxim. au crochet en régime continu
Légende
Loc. munie de l'échappt Nord (E Cz. N°1)
" d° " Nord (E Cz. N°5)
" d° " à trèfle (E Cz N°5bis)
" d° " Kylchap (E Cz N°5ter)
Etat de la locomotive lors de chaque essai
E Cz N°1
E. Cz N°5
E. Cz N°5bis
E. Cz N°5ter
Nombre de km parcourus par la loc après sa sortie des Ateliers ou après GRP au moment de l'essai
105 000km
2000km
28 500km
75 000km
Timbre de la chaudière
16Hpz
17Hpz
17Hpz
17Hpz
Diamètre des cylindres BP
610mm
660mm
660mm
660mm
(avec conduits de vapeur améliorés)
Type de l'échappement
Nord
Nord
P.L.M. (trèfle)
Kylchap
Serrage de l'échappement
0,7
0,7
0
Fixe
Section de passage
1dm2 60
1dm2 55
1dm2 68
1dm2 98
Type des injecteurs
1 HZCV de 75 à 12CV de 10 à vapeur vive
12CV de 10 à vapeur vive
1 Metcalfe à vapeur d'échappt
Recouvrement à l'échappt des cylindres HP
-3mm
0
0
0
Recouvrement à l'échappt des cylindres BP
-3mm
-10mm
-10mm
-10mm
O F = Effort au crochet en palier
O Pc = Puissance au crochet
AH = admission HP
AB = admission BP
E = Serrage de l'échappt variable
0 min.
1 max
F = Effort au crochet en palier
Pc = Puissance au crochet moyen en (en CV)
Vitesses en Km/h
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.500
2.500
40
60
80
100
120
F.10500
F.9087
F.8850
F.8700
F.7800
F.7102
F.6974
F.6806
F.6660
F.6532
F.5782
F.5110
F.5050
F.3900
Pc.1870
Pc.1893
R.1555
R.1967
R.2019
R.2016
R.2066
R.1988
R.1733
R.1579
R.1713
R.1923
R.1444
AH.60% AB.75% E.0
AH.55% AB.75% E.0,7
AH.55% AB.75% E.0
AH.50% AB.75% E.0,7

Fig. 3.

Explanation of French terms in figure 3:

Courbes des efforts et puissances maximum au crochet en régime continu = Curves of the maximum efforts and power, at the drawbar under continuous operating. — Loc. munie de l'échappt... = Loco. fitted with... blast pipe top. — Etat de la locomotive lors de chaque essai = State of the locomotive during each test. — Nombre de km. parcourus par la locomotive après sa sortie = Number of kilometres run by the locomotive after leaving the workshops or after general repairs at the moment of the test. — Timbre de la chaudière = Boiler pressure. — Diamètre des cylindres BP = Diameter of the low-pressure cylinders. — Type de l'échappement = Type of blast pipe top .— Serrage de l'échappement = Degree of opening of the blast pipe top. — Section de passage = Area of the passage. — Type des injecteurs = Type of injector. — Recouvrement à l'échappement des cylindres HP = Exhaust lap of the high pressure cylinders. — Recouvrement à l'échappement des cylindres BP = Low pressure cylinder exhaust lap. — Avec conduits de vapeur améliorés = With improved steam passages. — A vapeur vive = Live steam. — A vapeur d'échappement = Exhaust steam. — Effort moyen au crochet en palier = Mean tractive effort at drawbar on the level. — Puissance au crochet = Power at drawbar. — Admission H. P. = High pressure cut-off. — Admission B. P. = Low pressure cut-off. — Vitesses = Speeds.

general repairs during which the low-pressure cylinders were increased in diameter, the steam passages were altered, and the pressure raised from 16 to 17 Hpz (16. 32 to 17. 34 kgr. per cm^2 = 232.1 to 246.6 lb. per sq. inch). During these two series of tests the locomotive was fitted with a Nord type variable blast pipe top.

A third series of tests of short duration were made in August 1929 (E Cz No. 5*bis*) after substituting a clover leaf blast pipe top of P.L.M. type for the Nord type. Finally in March 1930, short tests (E Cz No. 5*ter*) were carried out with a fixed Kylchap blast pipe top. The table below gives the principal dimensions of the engine at the time each of these tests was carried out.

From these tests a certain number of characteristic curves for the locomotive were prepared. The most interesting of these are given in figures 3 and 4.

Figure 3 gives the pulls and powers at the drawbar, on the level, measured at constant output at the maximum evaporative capacity of the boiler.

The curves A (before alteration) and B (after alteration) show the improvement obtained by increasing the diameter of the low-pressure cylinders, the improvement in the circulation of the steam and the increase of the boiler pressure from 16 to 17 Hpz (16.32 to 17.34 kgr./cm^2).

The curves C show that the clover leaf blast pipe top, made it possible specially at average speed, to increase the evaporative power of the boiler, and consequently the high pressure cut-off, so that the power at the drawbar has been sensibly increased.

The few tests carried out with the Kylchap blast pipe top (test Cz No. 5*ter*) gave results which were in every way analogous.

As regards the consumption of fuel and water, under reserve of the inevitable errors in determining the quantity of fuel on the grate at the beginning and end of each test, the figures taken during the last test to which the engine was subjected in its present state, show first that the consumption of water was in the neighbourhood of 7.5 litres (1.65 Br. gall.), and the consumption of coal of the order of 1.1 kgr. (2.42 lb.) per H. P.-hour, at the drawbar, on the level, under the best conditions of use of the engine, that is to say for an average power at the drawbar of between 1 500 and 2 000 H.P.

Figure 4 shows comparison between the maximum efforts and power at the drawbar on the level, and under continuous operation of the locomotives of class 3 200 (4-6-0 type), class 31 000 (4-6-2 type) and 241 001, obtained by the same methods.

Whereas the adhesive weight of engine 241 001 only exceeds that of the 3 200, or of the 31 000 by about 30 %, the in-

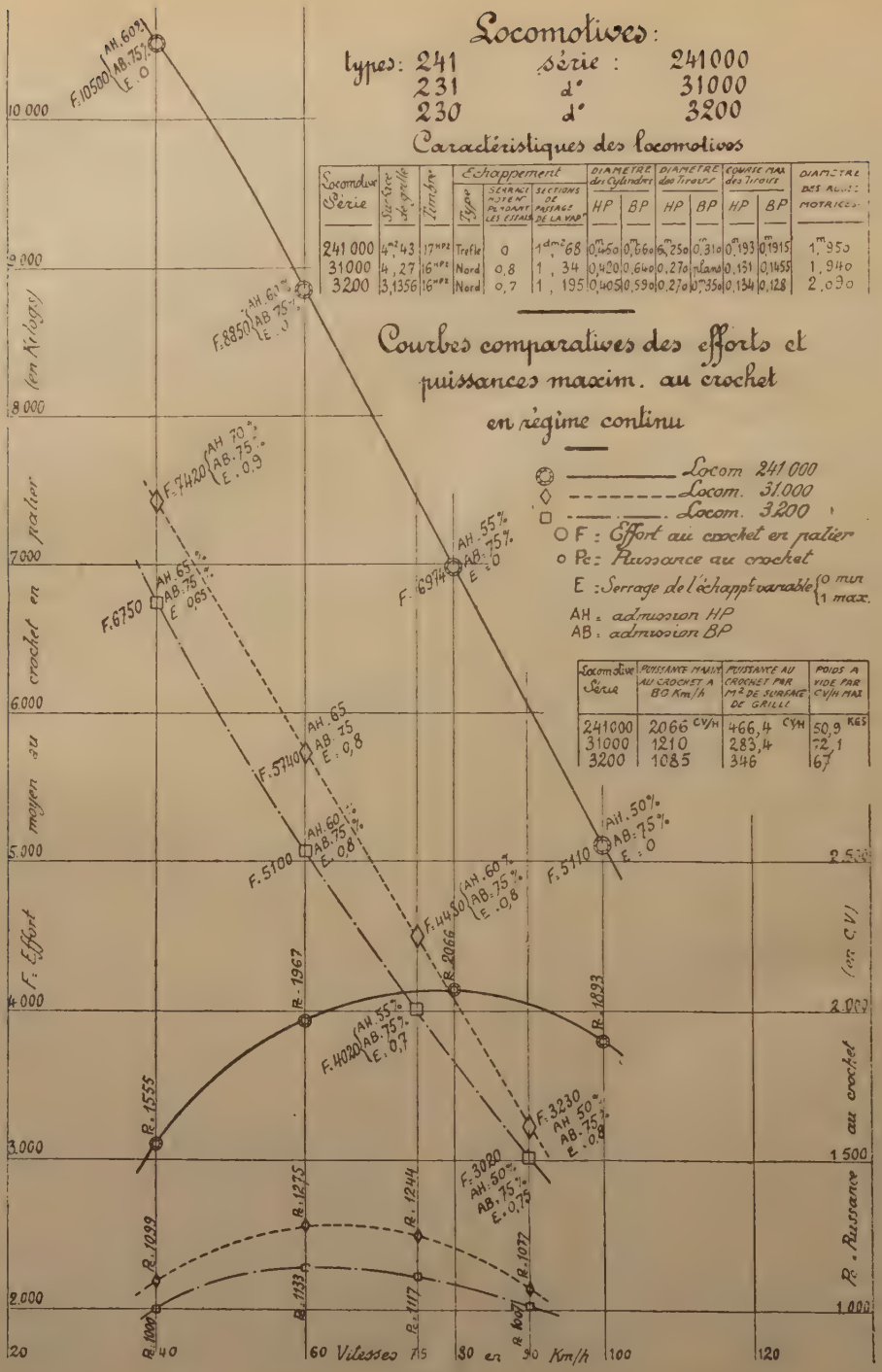

Locomotives :
types : 241 série : 241000
231 d° 31000
230 d° 3200
Caractéristiques des locomotives
Courbes comparatives des efforts et puissances maxim. au crochet en régime continu
Locom 241 000
Locom. 31000
Locom. 3200
F : Effort au crochet en palier
Pc : Puissance au crochet
E : Serrage de l'échappt variable 0 mini 1 maxi.
AH = admission HP
AB = admission BP
F. Effort au crochet en palier (en Kilogs)
F. moyen au crochet
R. Puissance au crochet (en CV)
Vitesses en Km/h

Fig. 4.

Explanation of French terms in figure 4:

Caractéristiques des locomotives = Dimensions of the locomotive. — Surface de grille = Grate area. — Timbre = Boiler pressure. — Echappement = Blast pipe. — Serrage moyen pendant les essais = Average degree of opening during the tests. — Sections de passage de la vapeur = Area of the steam passages. — Diamètre des cylindres = Diameter of the cylinders. — Diamètre des tiroirs = Diameter of the piston valves. — Course maximum des tiroirs = Maximum stroke of the valves. — Diamètre des roues motrices = Diameter of the driving wheels. — Courbes comparatives, etc... = Comparative curves of the maximum efforts and power developped at the drawbar under continuous working. — Effort au crochet en palier = Effort at the drawbar on the level. — Puissance au crochet = Power at the drawbar. — Puissance maximum au crochet à... = Maximum power at the drawbar at... km. — Puissance au crochet par m² de surface de grille = Power at the drawbar per sq. metre of grate area. — Poids à vide par C. V./H. max. = Empty weights per H. P. maximum, kgr. — Vitesses = Speeds. — Effort moyen au crochet en palier (en kilogr.) = Average tractive effort at the drawbar on the level, in kilogrammes. — Puissance au crochet (en C. V.) = Power at drawbar (in H. P.).

crease of the power available is definitely higher.

Under continuous operation at the maximum rate of evaporation, locomotive 241 001 developed at 80 km. (50 miles) per hour a power quite double that available at the drawbar of the 3 200 and the 31 000 locomotives, these two last locomotives developing actually very little different power at this speed.

When comparing the consumptions mentioned above and when remembering that the 4-6-0 type engine of the Est System has always been considered amongst the best type of express locomotives, we should consider that the results obtained with locomotives 241 001 are most satisfactory.

For this reason the Est Company has ordered 40 locomotives of the same type, which should be delivered during 1931. The power of these locomotives will be increased by increasing the pressure from 17 to 20 Hpz (17.34 to 20.40 kgr./cm² = 246.6 to 290 lb. per sq. inch).

Since its last general repair that is to say since March 1929, engine 241 001 has run 80 000 km. (50 000 miles) and covers very regularly the working of the fastest and heaviest trains on the Paris-Belfort line.

It has shown its speed and power in certain official tests, for example in October 1929, on the State Railways between Paris-and Cherbourg, with a train weighing 600 tons, and in January 1930 during steam heating tests on trains consisting of 15 to 18 bogie carriages, tests carried out by the « Office Central d'Etudes de Matériel de Chemins de fer » (O.C.E.M.), between Paris and Bar-le-Duc. Twelve consecutive runs were carried out at an average speed of 95 km. (59 miles) an hour with these trains, the weight of which varied between 575 and 690 t. (565 and 679 Engl. tons). This locomotive was then exhibited at Liége from March to November 1930, and since its return to the Est it continues to perform very hard service with great regularity. In February 1931 the heating tests were again taken in hand by the O.C.E.M. with a train of 780.5 t. (768 Engl. tons), 5 trains being worked between Paris and Bar-le-Duc, or in the opposite direction, at the average speed of 85 km. (52.8 miles) and hour. Finally the fast trains, for the international brake trials, carried out between Chaumont and Troyes by the brake sub-committee of the International Union of Railways, were hauled by this locomotive.

CURRENT PRACTICE

[621. 134 1]

London and North Eastern Railway S. 1 type 0-8-4 tank engine No. 6171, fitted with reversible booster.

Engine No. 6171, which is one of four used at the Wath Concentration Yard of the London & North Eastern Railway for pushing wagons over the gravitation hump, and originally put into service in 1907, has been re-built at Gorton to the requirements of Mr. H. N. Gresley, Chief Mechanical Engineer of the London & North Eastern Railway, and fitted with a reversible booster. The engine has three high-pressure cylinders, the centre cylinder driving on to the second pair of coupled wheels, the outside cylinders driving on to the third pair of coupled wheels.

The booster which was manufactured by J. Stone & Co. Ltd., Deptford, communicates its power to the leading bogie axle through gears, the trailing wheels of the bogie being coupled to the leading wheels by side rods. As these engines only travel at low speeds, the gear ratio of the booster is 1 : 2.71. The booster is steam controlled and can be cut in either to run forward or backward as may be required.

The tractive power of the engine at 85 % boiler pressure, without the booster, is 34 523 pounds and with the booster in operation this is increased by 12 373 pounds, making the total tractive effort of 46 896 pounds.

Diagram of steam control.

The sequence of the operations as indicated on the diagram, is as follows :

Boiler steam valve 1 is opened, and steam admitted through pipe 2, to the combined control steam valve 3, and preliminary throttle valve 4.

When steam valve 3 is opened it allows steam to pass through pipe 5 to the duplex reverse lever pilot valve 6.

To operate booster in forward gear :

The locomotive reversing lever 7, which is coupled to latch lifting lever 8, is moved to the forward position, causing latch lifting lever 8, to raise latch 9. This movement unseats valve 10, and seats valve 11, allowing the steam to flow past valve 10, through pipe 12, to the preliminary throttle valve 4, and at the same time, steam flows through pipe 13 to the underside of clutch cylinder piston 15 in clutch cylinder 16, and to the rocker stop cylinder 14.

On the opening of the preliminary throttle valve 4, the steam passes through choke 17, and pipe 18, into the main booster steam pipe 19, allowing the booster to revolve slowly and the gears to mesh.

When steam enters pipe 13, ball valve 20 is forced on to its opposite seat, thereby isolating the pipe to the backward side of the duplex reversing lever pilot valve 6.

When the piston 15 in clutch cylinder 16 has moved upwards, and the gears have meshed, it uncovers steam port 21 and allows steam to flow through pipe 22, to the main throttle valve operating cylinder 23, which opens booster main throttle valve 24, and admits steam at full boiler pressure from the locomotive superheater through main stop valve 25, into the main booster steam pipe 19.

When steam pressure has built up in main booster steam pipe 19, which is fitted with a non-return valve 26, steam

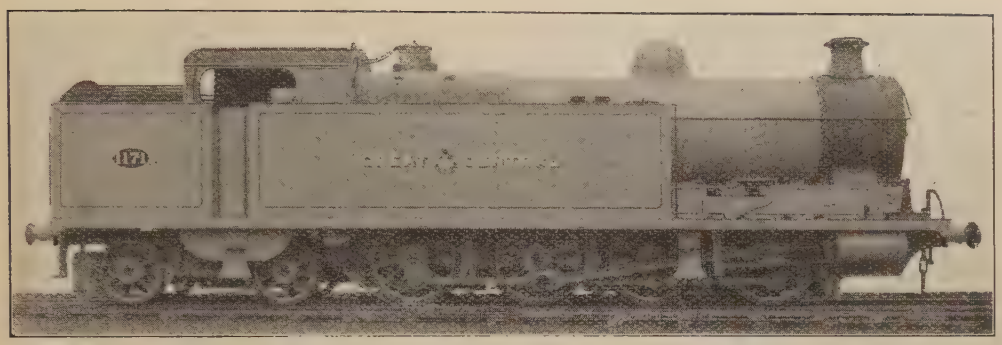


Fig. 1.

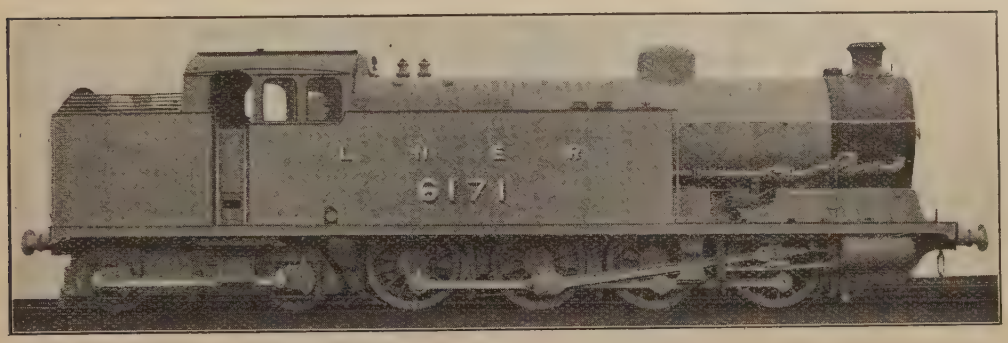


Fig. 2.

through pipe 27 enters the delay action valve 28, which controls the booster cylinder relief cock operating cylinder 29.

The steam on entering the delay action valve 28 causes the piston 30 to close the exhaust valve 31. The steam then passes slowly through needle valve 32 and pipe 33, and slowly builds up pressure behind the piston of cylinder relief cock operating cylinder 29.

When sufficient pressure to overcome the resistance of spring 34, has been built up, the piston moves in the direction of arrow, and allows the steam in the booster cylinders to automatically shut off the cylinder drain cocks 35 and 36.

A small hole 37 is made in the preliminary throttle valve 4 to permit a small amount of steam being fed to the booster cylinders, in order to keep them warm in cold weather.

To run the booster engine out of gear :

The idling valve 38 shown in the duplex reversing lever pilot valve 6 is turned, thus isolating the passage to the inlet valves 10 and 39. This allows steam to flow direct through pipe 12 to the preliminary throttle valve 4.

On the opening of the preliminary throttle valve 4 the steam passes through choke 17 and pipe 18, into the main booster steam pipe 19, causing the booster to revolve.

The exhaust steam from the booster

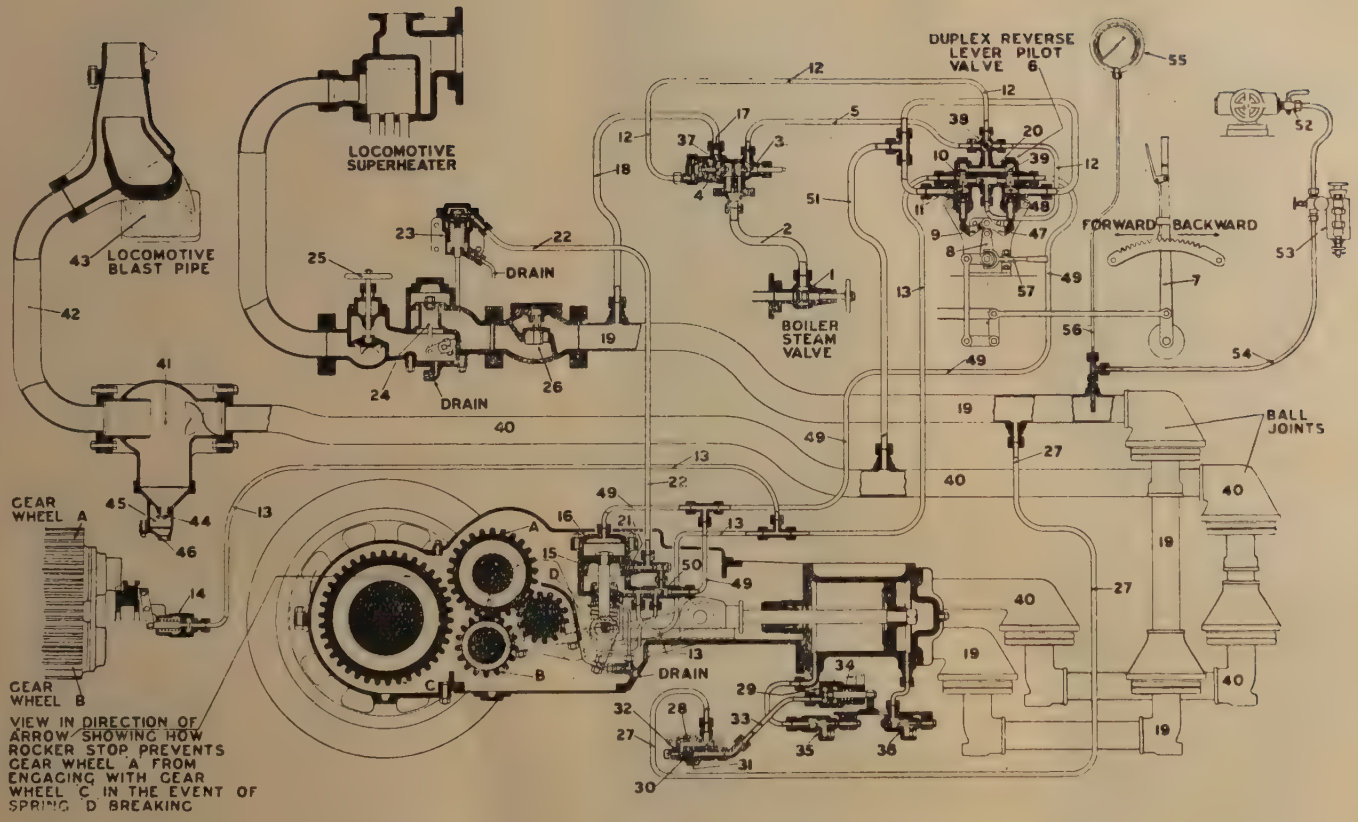


Fig. 3. — Diagrammatic layout of booster and connections showing steam control.

cylinders, passes through pipe 40, to the steam separator 41, and thence through pipe 42 into an annular space in the locomotive blast pipe 43, and to atmosphere in the ordinary way.

Valve 44 in the steam separator 41 which is balanced by counterweight 45 is operated by the weight of the trapped moisture in the chamber, the moisture being allowed to drain through the opening 46.

To reverse the booster :

The locomotive reversing lever 7 is moved to the backward position. This causes latch lifting lever 8, to raise latch 47, which closes valve 48 and opens valve 39, allowing steam to force ball valve 20 on to its opposite seat, and flow through pipe 12 to the preliminary throttle valve 4, which opens as for forward gear, and supplies steam through choke 17 and pipes 18 and 19, to slowly revolve booster. At the same time, steam flows through pipe 49, closes ball valve 50 to prevent steam entering the underside, and enters the topside of piston 15 in clutch cylinder 16. The piston 15 is depressed and the slowly revolving booster gears mesh.

The booster cylinder drain cocks 35 and 36 are operated exactly as in forward gear.

Exhaust steam from the duplex reverse lever pilot valve 6 flows through pipe 51, into the booster exhaust pipe 40, and then through steam separator 41, pipe 42 and blast pipe 43 to atmosphere.

The booster engine valves and cylinders are lubricated by means of a sight feed lubricator 53, to which steam is supplied from combination stand on boiler, through steam cock 52, and oil is fed into the main booster, steam pipe 19, by pipe 54.

The pressure gauge 55 is connected by pipe 56 to the booster main steam pipe 19.

A clutch 57 is fitted to throw the latch lifting lever 8 out of gear with latches 9 and 47, thus enabling the locomotive to be worked without the booster, and without interfering with any part of the booster operating gear.

MISCELLANEOUS INFORMATION.

621.335 & 621.43]

1. — The Baldwin Diesel-electric locomotive.

(Les Chemins de fer et les Tramways.)

The Diesel-electric locomotive, the total weight of which is available for adhesion, used as a shunting engine to haul heavy trains is now being employed on a greatly extended scale in the United States of America. Thanks to the heavy axle load allowed in America, the tractive effort of a B-B (0-4-4-0) locomotive can be very high and the use of the Diesel-electric locomotive makes it possible to haul loads even higher than those pulled by the steam shunting locomotive. The fact that these new locomotives can be started up immediately, their ease in driving, their ready manœuvrability, their low fuel consumption and their easy maintenance, makes them particularly suitable for shunting work in large stations.

A new engine of this type, the Baldwin Diesel-electric locomotive No. 61000, has been tested in 1931. This engine, having a nominal power of 1000 H.P. and a total weight of 270 000 lb., has shown itself able to haul trains of 2 000 to 4 500 tons. The locomotive was lent to and tested in shunting yards of six different railways (The Pennsylvania Railroad, the Illinois Central, the Chicago, Rock Island and Pacific, the Atchison Topeka and Santa-Fe, the New York-Chicago and Saint-Louis, and the Northern Pacific), and in this way has run a total distance of about 24 000 km. (15 000 miles), in practically continuous shunting service of about 4 000 hours.

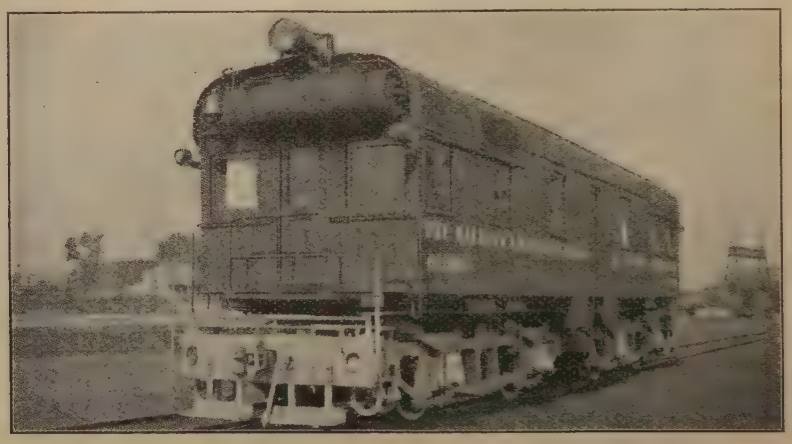


Fig. 1. — Baldwin locomotive.

This engine was also tested out in the open mines of the Oliver Iron Mining Company (Minnesota State), where it worked regularly heavy mineral trains.

This locomotive, the whole weight of which is adhesive, is of the B-B (0-4-4-0 type). Its dimensions and principal characteristics are the following :

Length over buffers	15.545 m. (51 ft. 0 in.)
Length of the body	13.411 m. (44 ft. 0 in.)
Width overall	3.200 m. (10 ft. 6 in.)

Overall height above rail	4.794 m. (15 ft. 8 3/4 in.)
Total wheel base	10.820 m. (35 ft. 6 in.)
Rigid wheel base of each bogie	3.200 m. (10 ft. 6 in.)
Diameter of the wheels	1.220 (4 feet)
Diameter and length of journals	216 × 381 mm. (8 1/2 in. × 15 in.)
1 Diesel-electric set :	
Nominal power	1 000 H. P.
At the speed of	500 r. p. m.
Diesel-Krupp engine	4-stroke, 6 cylinders with airless injection.
Bore of cylinders	381 mm. (15 inches)
Stroke of piston	381 mm. (15 inches)
Main generator, Westinghouse	Type 478 A
4 traction motors type 355, gear ratio	16/76
Voltage at the terminals in normal running	500
Electro-pneumatic control gear :	
1 battery of accumulators, service voltage	30
1 air compressor.	
4 motor ventilating fans.	
2 driving compartments.	
Fuel oil capacity	3 020 l. (675 Br. gall.)
Weight in working order :	
Diesel set	47 000 lb.
Total weight	270 000 lb.
Tractive effort at starting	67 500 lb.

From the point of view of construction, this locomotive is of the usual type. The novel features are to be found in the way the work has been carried out, and in the use and arrangement of the auxiliaries.

The locomotive as a whole consists of a body carried on two symmetrically arranged and spaced bogies. These motor bogies are articulated together and take the buffing and draw stresses set up when hauling the train. The body being set free from these large stresses is therefore very simple and is light and of a simple type of construction.

The bogie with two motor axles (total adhesion) has frames of cast steel. The side frames in cast steel are of the bar type; they include the usual axle boxes and axle guards.

The main springs carrying them rest directly at their centres on the axle boxes; they are arranged in pairs fitted on both sides of the side frames and are connected together at their ends so as to support the corresponding longitudes. This arrangement results in the bogie centres being lowered and consequently the body of the locomotive.

The side members of the bogie are connected together by the head stocks and by the centre bolster, all these parts being made of cast steel. The head blocks carry : one the buffers and the draw gear of the locomotive; the other the parts used for the articulation and coupling together of the two bogies. The first has a coupling with two twin springs of the Harvey type, a connecting arrangement with two Farlow locking pins, and finally the type D central coupling. The second end head stock carries the buffing gear and the coupling bar which gives the articulation. The centre bolster is of cast steel in one piece; this casting carries not only the centre, but also all the supports or bearings for the following parts : brake levers, brake gear fulcrum, spring gear of the motors, side bearings and brackets carrying the brake cylinders (these latter are actually fitted to the bogies).

The whole bogie built up in this way is very rigid; the elasticity given by the four groups of springs is ample for the heavy loads and the low speeds required in operation; the

speed does not exceed 40 km. (25 miles) per hour. The articulation of the bogies has made it possible to find room for the coupling gear details readily, the coupling even on curves remaining quite close to the centre line of the track. This is not the same when the coupling is fitted on the end members of the body of the locomotive. It consequently would seem that the articulation of the bogies themselves is very desirable on shunting locomotives.

The body is not of the type forming as it were a tube in itself; it includes a quite substantial frame. This frame is in cast steel in one piece and is 13.411 m. (44 feet) long. It is carried on the bogie centres and supports at each end the equipment in the driving compartments and at the centre the engine room section with its Diesel-electric motor generating set of 1 000 H. P. and all the auxiliaries involved. The two driving compartments, one at each end of the locomotive, are separated from the engine room by partitions; communicating doors are provided however to connect the three compartments together. The ventilation of the different apparatus (Diesel motor set and auxiliaries) is made by motor ventilating sets giving, either into the roof or at the top of the sides of the locomotive, a supply of air. We will deal with this again further on; it should be noted however, that the five ventilators mounted in the roof above the engine room (see the view from above) are easily got at; this portion of the roof in fact, can be lifted away in one piece to enable them to be examined and if need be the taking down not only of the Diesel motor, but of the main generator or of any part of the equipment of this group and its auxiliaries.

Diesel motor. — The Diesel motor is a Krupp motor with 6 cylinders working on the 4-stroke cycle with airless injection. This motor is able to give a power of 1 000 H. P. at 500 revolutions per minute. In practice it works between 250 and 500 revolutions per minute; its running speed light is 250 revolutions per minute. It weighs 47 000 lb. including the fly-wheel and the silencer. Its consumption is about 0.210 kgr. (0.465 lb.) of fuel oil per B.H.P.-hour, this oil having a calorific value of 10 400 cal. per kgr. (18 700 B.T.U. per pound) and the mean pressure at the motor being 9.5 kgr. per cm² (135 lb. per sq. inch.).

These figures have been recorded during the tests. In the same way the consumption of lubricating oil (including that of the auxiliaries) is 1.892 litres (0.810 Br. gallon) per 2 000 H.P.-hours.

The mechanical efficiency of the whole motor generator set, that is to say taking into account losses of energy due to the different auxiliaries (various pumps and air compressors) is 73 % under full load at full speed.

The wear of the motor was measured up after 2 500 working hours. All the parts were taken down. No appreciable wear was found in the crank shaft; the bearings taking the main thrust showed slight wear as did the bearings of the driving rods (big ends), the bearing surface of which was renewed. The piston rings were also renewed. As regards the cylinder wall a wear of 0.076 millimetre (0.003 inch) was measured.

The above is the result of the cooling and the lubrication having been particularly good. The circulating water and the lubricating oil of the engine are cooled separately; furthermore the pistons themselves are cooled by means of oil which, when the motor is stopped, continues to run for 10 minutes at the rate of 170 l. (37 Br. gallons) under a pressure of 1.97 kgr./cm² (28 lb. per sq. inch). This system of circulation has its own motors and its own radiators. All these radiators are moreover of the same type : « Modine turbotube », and all are mounted as we have already seen above. The radiators of the circulating water to the cylinder jackets are arranged at the back end of the locomotive; the radiators for the cooling oil of the pistons are placed on the right and left sides of the body at the back end. The radiators for the lubricating oil are placed on the right and left side at the top and at the leading end. The characteristics of cooling of these three sets of radiators taken for an air speed of 1 600 feet per minute are as follows :

Radiators	Circulating water.	Oil for pistons.	Lubricating oil.
Cooling surface, sq. feet	30	15	15
Quantity of heat absorbed, B. T. U. per minute.	33 450	9 300	3 315
Amount circulated, Br. gallons per minute.	248.7	142.6	71.3

The fresh air required for cooling these different sets of radiators is obtained from four groups of motor-ventilators (two at the front and two at the back — see view, fig. 2), of the Betz type with vertical axes; they are mounted in the roof of the body at the ends. These ventilators made of aluminium alloy each have eight blades ; their outside diameter is 1 m. (3 ft. 3 3/8 in.) and they give 28 750 cubic feet of air per minute. (They were built by Siemens-Schuckert). The 4 motors driving them have a nominal power of 15.5 H. P.; they take their current directly from the main generator.

The Diesel motor is started up by means of compressed air.

This is taken from a reservoir at a pressure of 25 kgr. (355 lb. per sq. inch) in the machine section. It should be noted that the motor may be made to run under overload with a higher pressure of air of 0.42 kgr./cm² (6 lb. per sq. inch).

Electric equipment. — The main generator supplying directly the traction motors and auxiliary motors is connected to the Diesel motor through a flexible coupling mounted on the motor fly wheel; this coupling consists of 18 sets of spring blades.

The whole motor genefator set so arranged has its axis of rotation 2.133 m. (7 feet) above the rail. The centre of gravity of the locomotive is therefore relatively low.

The whole of the electric equipment of the locomotive was supplied by the Westinghouse Electric and Manufacturing Company. The main generator is a compensated wound machine specially adopted for traction. The excitor acting on the inductor is mounted directly on the generator. The maximum tension in normal service at the generator terminals is about 500 volts, and its angular speed varies between 250 and 500 revolutions per minute.

The 4 traction motors (one per axle) are the usual type for heavy trains. Switches (one for each motor) connect them to the terminals of the main generator, the regulation of which is sufficient to cover the variation of power necessary when working the trains. Each traction motor drives its axle through twin gears of a ratio of 16/76. As soon as the running speed exceeds a pre-determined value the inductors of the traction motors are shunted by means of suitable switches and a more economical running is obtained.

The control gear is of the electro-pneumatic type. It acts both on the admission side of the Diesel motor and on the moment and output of the main generator. Whereas the maximum speed of the Diesel motor is set at 500 revolutions per minute by a special automatic regulator, the normal speed of the motor generator group lying between 250 and 500 revolutions per minute is regulated by the admission regulator of the Diesel. The connection between this latter and the « master controller » (which acts upon the resisting moment and the output of the main generator), is obtained by means of a hydraulic auxiliary cylinder commander by a lever mounted on the controller shaft.

This cylinder acts through a tubular connection upon the admission of another hydraulic cylinder which replaces a cam mounted on the admission regulator. The moment regulator acts on the commutator and the inductors of the generator so that the resisting moment of the generator does not exceed the motor moment of the Diesel. In this way the regulation of the power supplied to the traction motors and that of the Diesel motor are regulated at the same time.

The control of the direction of running of the locomotive is obtained by the usual type of inverters of the drum type the position of which is controlled through electro-valves,

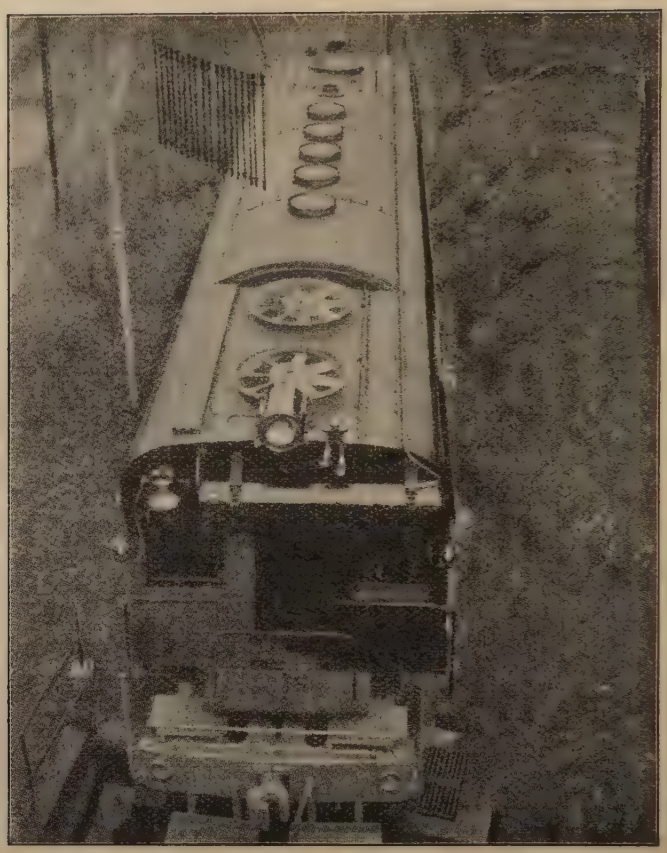


Fig. 2. — Baldwin locomotive. Top view showing air circulating fans.

the action of which varies according to the position given to the change lever mounted on the « master controller ». This reversing lever at the same time cuts the control circuits (if need be) and starts up the motor of the oil pump used to cool the Diesel pistons when the latter stops.

As in the case of electric locomotives we have the traction circuit (here at 500 volts) and the control circuit. The latter is fed by means of a battery of accumulators consisting of 15 Exide-Ironclad-MVA-II cells giving a normal service voltage of 30. In this circuit is connected the 2-H. P. motor at 1 500 revolutions per minute driving the oil pump for cooling the Diesel pistons.

The lighting of the locomotive (driver's cabins and lamps) is also arranged on this circuit.

The compressed air required for the electro-pneumatic equipment for the brakes and for starting the Diesel motor is given by a compressor driven directly by the Diesel motor and feeding reservoirs of compressed air carried in the engine room and holding 690 l. (42 000 cubic inches) of air compressed to a pressure of 25 kgr./cm² (355 lb. per sq. inch). The principal reservoirs for the brake are ar-

ranged above the doors and outside the locomotive at each end (see the 2 figures); these 2 main reservoirs each have a capacity of 410 l. (25 000 cubic inches). If the pressure of the brakes falls below 8.08 kgr./cm² (115 lb. per sq. inch) the reservoirs at a pressure of 25 kgr. (355 lb. per sq. inch) in the engine room enable the brake to be re-charged.

The compressed air also is used to work the two-tone signalling whistles and the warning bells placed at the front and back ends of the locomotive above the doors and beside the main brake reservoirs.

Driving compartment. — Each driving compartment at the front and at the back contains all the control gear required both for driving the train as for supervising the Diesel motor and its auxiliaries. Behind the driver's seat are the controller, the brake valves, and the switch board. On this the gauges and meters, switches, lighting, and control equipment and the various measuring devices are fitted. In the driver's compartments are also to be found the valves controlling the warning bells, and the sanding gear. There is also in each and in the top of them; a tank of fuel oil containing 1 510 l. (332 Br. gallons) for supplying the Diesel motor. Between the two compartments a pipe connects together the two tanks thereby levelling them up so as to avoid any alterations in the loads on the axles while running.

The engine room contains the Diesel-electric set and all the accessories described above as well as the control gear not included in the « master controller ». These latter are fitted at the end of the generator. The battery of accumulators is installed in an open container on the left side. The reservoir of oil for cooling the pistons is fitted in the upper portion (back end): in this way when the Diesel engine is stopped, the pressure of the oil through this difference in level with regard to the ventilating pump is sufficient to start up the latter.

In this same engine room there is an instrument board relating to the running of the Diesel-electric group; it contains the following apparatus : a pyrometer, giving the temperature of the exhaust of each cylinder; a speed indicator, showing the revolutions of the motor, a voltmeter and an ammeter, the switches for lighting and the recorders of the pressure in the oil circuits to the radiators.

We have seen that the tractive effort at starting of this locomotive was 30.6 t. (67 500 lb.); this effort can be maintained owing to the electric transmission and its regulation, up to a speed of 8 km. (5 miles) per hour, which corresponds at this moment to a developed power at the rim of 910 H. P. Such results can only be obtained with a machine of the B-B (0-4-4-0) type, with a high axle load; it is here about 30.5 t. (67 460 lb.). This is equivalent to say that the success of powerful Diesel electric locomotives is a function of the strength of the track. For this reason this type of engine will develop more quickly in the United States than with us. It would be easy, it is true, to correct the weaker permanent ways by using Diesel electric engines coupled together with multiple-unit control.

The economy of fuel consumption shown by the Baldwin locomotive may be taken as follows : 2.06 gr. of fuel oil per wagon-km. (0.116 ounce per wagon-mile) hauled instead of 14.5 gr. (0.82 ounce) of coal, when using a steam locomotive hauling a wagon under the same conditions. The above translates itself in the United Sates into a saving of 45 % in the cost of fuel. This figure is sufficient to justify the purchase of Diesel-electric shunting locomotives.

D. L.

621 .335 & 621 .43]

2. — 450-H. P. Sulzer Diesel-electric locomotive for the Royal Siamese Railways.

(Revue Générale des Chemins de fer.)

Messrs. Sulzer Bros. of Winterthur have just carried out trials with one of the six 450-H. P. Diesel-electric locomotives they have built for the Royal Siamese Railways.

These tests were carried out on the Landquart-Coire-Disentis line of the Rhætic Railway Company.

The leading dimensions of these locomotives (fig. 1) are as follows :

Gauge	1 m. (3 ft. 3 3/8 in.).
Length over buffers	13.590 m. (44 ft. 7 in.).
Distance between bogie centres	7.400 m. (24 ft. 3 3/8 in.).
Bogie wheelbase	3.000 m. (9 ft. 10 1/8 in.).
Number of driving wheels	8
Number of carrying wheels	4
Weight in working order	About 60 tons.
Minimum adhesive weight	About 43 tons.
Diameter of driving wheels	914 mm. (3 feet).
Diameter of carrying wheels	762 mm. (2 ft. 6 in.).
Sulzer Diesel motor	8 cylinders.
Continuous power rating :	
at 700 rev. per minute	450 H. P.
620 rev. per minute	400 H. P.
530 rev. per minute	340 H. P.
Maximum hourly speed of the locomotive.	60 km. (37.3 miles).
Tractive effort, hourly rating, at 20.5 km. (12.7 miles) per hour	4 150 kgr. ((9 150 lb.).
Maximum tractive effort	9 400 kgr. (20 720 lb.).

Description of the Sulzer-Diesel engine. — The Sulzer-Diesel motor is a 4-stroke, 8-cylinder engine (fig. 2), consisting of two four-cylinder blocks. The main crank case is made of cast steel, the connecting rods are made of nickel-chrome steel, and the pistons of aluminium alloy. The total weight and especially that of the moving masses has been greatly reduced thereby.

The motor works on the principle of the solid injection of the fuel into a pre-combustion chamber. The necessary pressure for atomizing is obtained by the partial combustion of the fuel in the pre-combustion chamber.

By this method the injection pressure is kept relatively low, an important factor as regards regularity of working. Each cylinder has its fuel pump located between the inlet and exhaust valve push rods of the cylinder. It is driven directly off the cam shaft and pumps the fuel into the pre-combustion chamber. The quantity of fuel is automatically adjusted to the power required by means of the centrifugal governor whereby the speed of the motor is kept constant.

In order that the Diesel motor may be the better adapted to the working requirements it has been designed to work at three different speeds. The change from one speed to another as well as starting up and stopping the motor is controlled from the driver's cab. When running down gradients and when standing, the motor can be stopped and this gives a far from negligible further saving of fuel. To start the motor up again only requires a few seconds.

The cooling water of the motor is cooled in radiators arranged along the sides of the

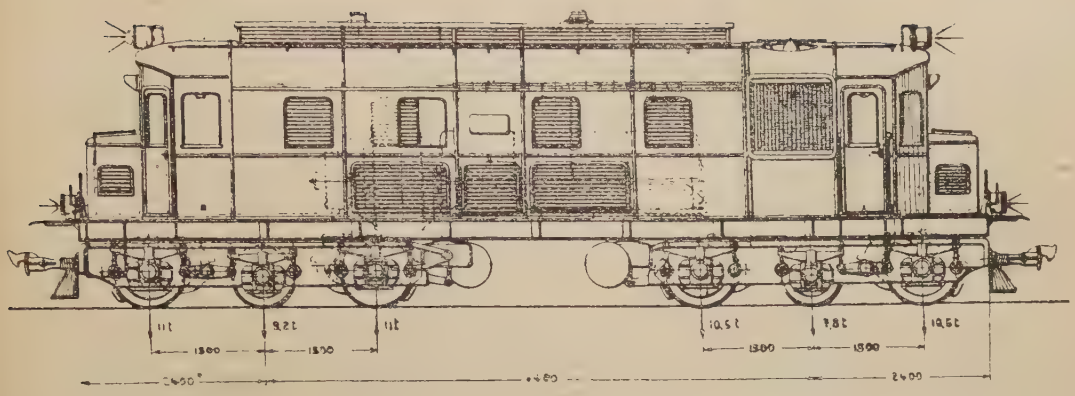


Fig. 1.

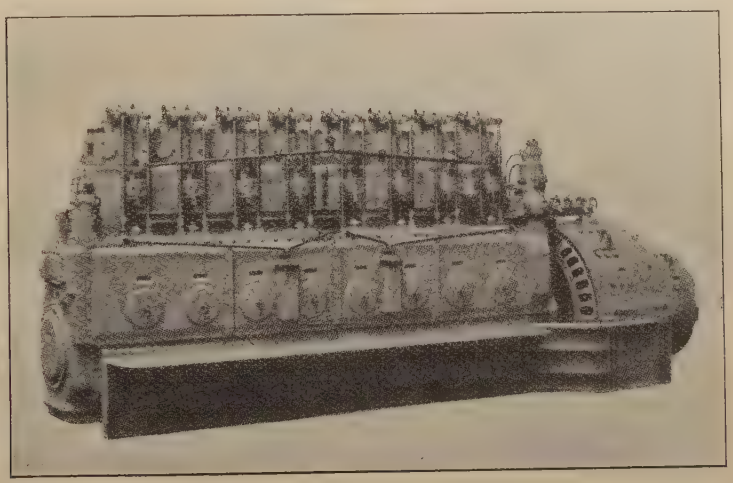


Fig. 2.

locomotive. Two fans each driven by an electric motor, draw air through the side of the radiators and drive it through an opening in the roof. The speed of the fans can be reduced by « by-passing » the field winding and thereby reducing the extent to which the water is cooled.

The lubricating oil coolers are combined with the cooling water radiators.

Operation of the main generator. — The Diesel motor and the generator are rigidly coupled together.

The main circuit connects the main generator to the four traction series motors connected in parallel. The controller in each cab is used to insert resistances between the armature of the auxiliary generator and the field of the main generator the excitation of which can also be varied. By this method the tractive effort can be regulated to suit requirements. As a result of the layout of the Diesel-generator set and its control the locomotive can be driven by one man. In addition the supply of fuel to the Diesel engine as well as the lubrication and the cooling of

the circulating water are fully automatic, so that the presence of a driver in the engine room is quite unnecessary.

The Diesel engine is started up by running the main generator as a motor off the accumulators.

The main generator is automatically ventilated by a fan keyed to its shaft. The four traction motors, which are of the nose-suspended type, are also self ventilating; they drive the axles through reduction gears. Each motor has a distance-controlled contactor and a miximum current cut-out. A switch electro-pneumatically controlled from the driving compartment reverses the field of the four traction motors simultaneously when changing from forward to backward running and inversely.

Function of the auxiliary generator. — The auxiliary generator which provides the current for the auxiliary machinery, for charging the accumulators and for exciting the main generator is coupled to the latter and consequently runs at the same speed (1).

The auxiliaries, which have to work when the Diesel motor is stationary, or during the time that the locomotive is not running, as for example the exhauster and the auxiliary compressor, are coupled up to the battery.

The battery is placed in boxes at the two ends of the locomotive. The charging contactor automatically completes the circuit as soon as the tension of the auxiliary generator reaches 130 volts. A relay cuts the circuit as soon as the tension at the terminals of the auxiliary generator falls below that of the battery. The fans of the radiators are driven by series motors connected directly to the terminals of the auxiliary generator. These motors are not coupled up to the battery as they only run when the Diesel motor is working.

The circulating water pump is driven by a series motor with weak compounding which starts up automatically as soon as the Diesel engine is set running. The water pump can be kept running by means of a switch in the driving compartment, when the Diesel motor is stopped. The cooling of this motor can in this way be continued during stops.

The exterior and interior lighting of the locomotive is supplied by accumulators. The power of the head lights can be regulated through a resistance.

Driving and control apparatus. — Each driving compartment contains a controller, a lever for forward and backward running combined with the speed control of the Diesel engine and also a handle for starting up and stopping this engine. The switch for the vacuum pump and that for the water pump mentioned above are placed conveniently for the driver who has before him the following indicating instruments : revolution counter for the Diesel engine, wattmeter for the power of the main generator, ammeter for the current of the traction motors.

By means of the first two of these instruments, the running of the Diesel motor can be controlled normally from the driver's compartment. In the event of one or several cylinders not working, for example through a defect in the fuel supply, the load would be automatically taken up by the other cylinders through the action of the regulator and they would be overloaded. To overcome this defect the driver has an indicator which shows the position of the regulator and thereby immediately reveals to him the irregularity. The apparatus also includes sight glasses in the pipe lines through which the circulation of the oil and cooling water can be seen.

A speed indicator is placed in each driving compartment, one of the two being fitted with a recording device.

The locomotive is vacuum- and hand-brake fitted. Each bogie has air sanders on all driving wheels for both directions of running.

Other constructional details. — The body of the locomotive is built up of a steel frame covered with steel panels. The roof of the engine room can be lifted off. It is designed

(1) This group is carried on an auxiliary frame built up of steel plate and rolled sections carried on the main frame of the locomotive.

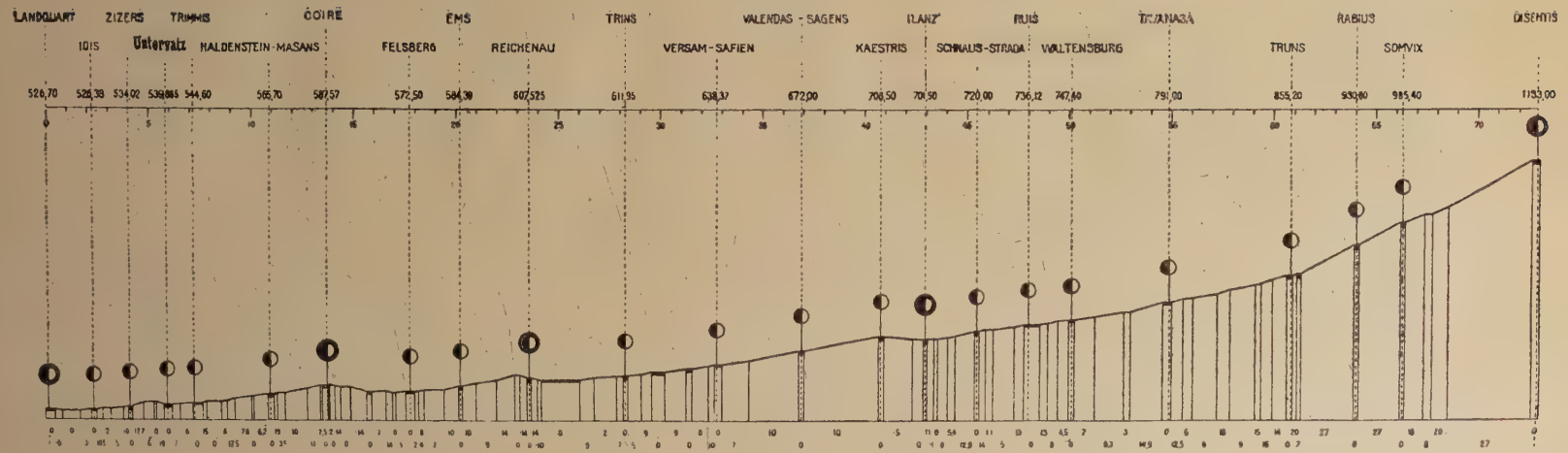


Fig. 3.

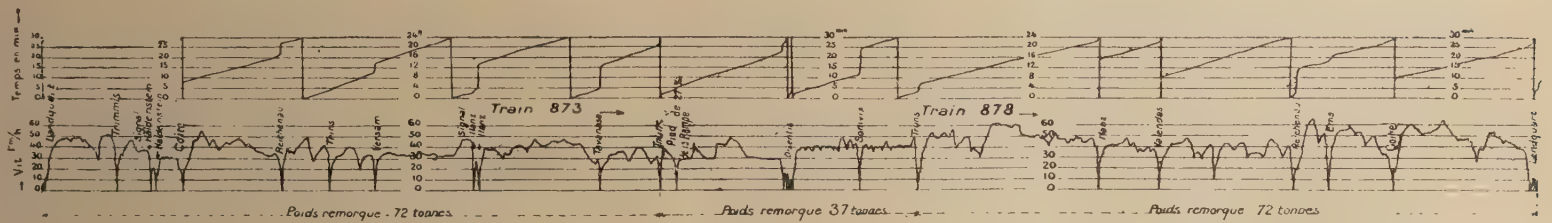


Fig. 4.

Note : Vit. = Speed. — Temps en min. = Time in minutes. — Poids remorqué = Weight hauled.

to carry the fuel and water tanks and also the silencer.

The regulating resistances are placed in the roof and are protected by a metal casing. The partition between the engine room and the driving compartments is built up of reinforced sheeting. The floor in the engine room on both sides of the Diesel engine is double, the lower floor being of plate and the upper, the floor proper, of teak planking; the cables and pipes are run in between them. The frame of the locomotive is built up of rolled sections. The buffing and draw gear is carried on the bogies. The main frame is carried on the bogies by spherical pivots and side rubbing blocks.

Result of trials. — The tests carried out the 14 July 1931 gave the excellent results shown in figures 3 and 4, which reproduce the profile of the Landquart-Coire-Disentis line of the Rhætic Railway Company and also opposite to one another the diagram of the times for the distances covered and that of the speeds obtained on this line which has maximum gradients of 1 in 37.

The actual fuel consumption was 10 gr. per ton-km. (9.2 drams per Engl. ton-mile) for the whole train including the locomotive.

These results make it reasonable to think that owing to its many advantages Diesel-electric traction will find more and more frequent applications on certain railway lines. In fact these vehicles must no longer be considered as experimental but as engines of equal reliability in working as the locomotives usually employed.

NEW BOOKS AND PUBLICATIONS.

[385 .587 (.43), 621 .138 .5 (.43) & 625 .26 (.43)]

DEUTSCHE REICHSBAHN GESELLSCHAFT (German State Railway Company). — **Dienstvorschrift für die Ausführung von Zeitaufnahmen in den Reichsbahn-Ausbesserungswerken und den Ausbesserungsbetrieben der Bahnbetriebs- und Bahnbetriebswagenwerke. (Instructions on the timing of operations in the main workshops in the running repairs shops, and in the wagon shops).** — A pamphlet (11 1/2 × 8 1/4 inches) of 24 pages, with 25 appendices (tables and graphs). — Berlin, 1931, published by the German State Railway Company.

During the last few years scientific methods have develloped very quickly in the railway rolling stock repair works; whereas at first such methods were considered as only applicable to new work under mass production methods they have progressively extended to the maintenance and repair of rolling stock and have undoubtedly had the most happy results as regards output of these works.

One of the principal problems raised when scientifically organising the shop methods is the investigation of the time required for the different operations. As early as 1921 the Reichsbahn had set up at Headquarters a special department for ascertaining such timings.

The investigations into the timing of repair operations first taken in hand in some of the main shops have been extended first of all to the whole of these shops and subsequently, as a result of the favourable results obtained, to the maintenance shops. The pamphlet published by the Reichsbahn is the result of six years' practical experience in taking such timings : it summarises the different instructions which have been elaborated in turn during this period.

The first paragraph describes the object of taking operation times : determination of the most economical method, study of the worker's movements, fixing the time elements on which are based the instruction cards and the piece work rates.

The second paragraph gives a series of basic definitions which elucidate the ideas of the elemental operations and times; these are indispensable for the uniform and practical arrangement of the regulations in connection with timing. The third paragraph deals with the composition of the timing gang, describes the functions and duties of the timesetters.

The description and use of the necessary accessories, chiefly watches and time cards used in connection with the timing of operations are found in the fourth paragraph.

The following chapters deal with the practice of timing the preparatory operations and the timing of the execution of the work properly speaking, and give the method whereby the time for an operation is set in terms of the detail observations made.

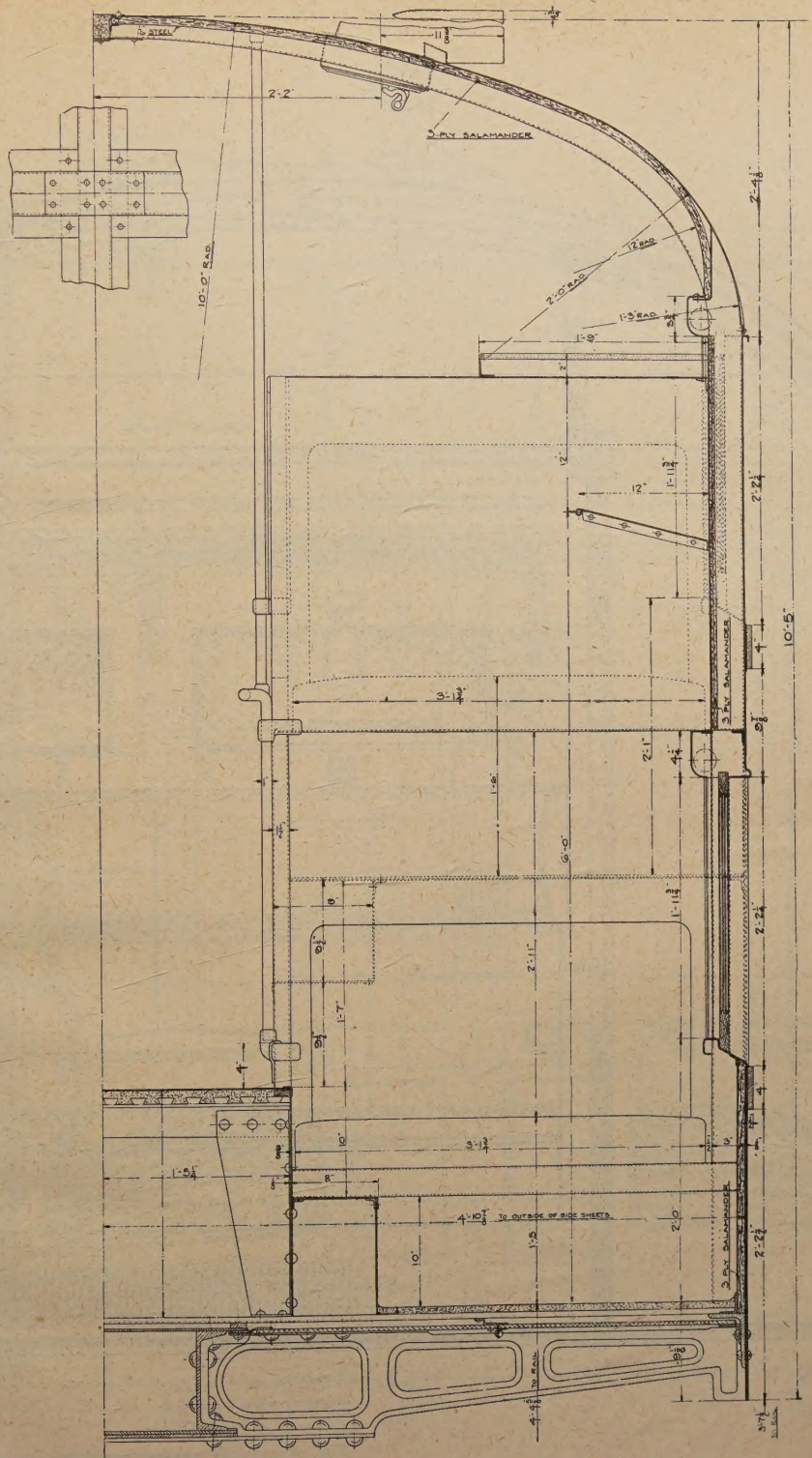
Two fully worked out examples, one on work done by an individual and one for a gang, illustrate the plan of the method.

The last two paragraphs deal with the determination of lost time and the times allowed the charge hand of a gang : examples are given to show the practical application of the rules stated.

An appendix to the pamphlet contains the whole of the formulæ and standard cards used in timing work, a number of them properly completed are the concrete examples of application explained in the text.

The detailed and systematic timing of all operations appear therefore to the Reichsbahn as the only way of establishing on a sound basis the scales of time allowances for repair work and for fighting against the lost time which is so prejudicial to the output; the tests and the work done by its specialised timing gangs have resulted in the remarkable unification of operating methods in all its workshops; these regulations thus form a particularly interesting contribution to the investigation into the scientific organisation of railway rolling stock repair work.

A. C.



Note : Entire construction of aluminium or copper bearing steel.

Fig. 2. — Vertical cross section of semi-double deck passenger carriage, Pennsylvania Railroad.

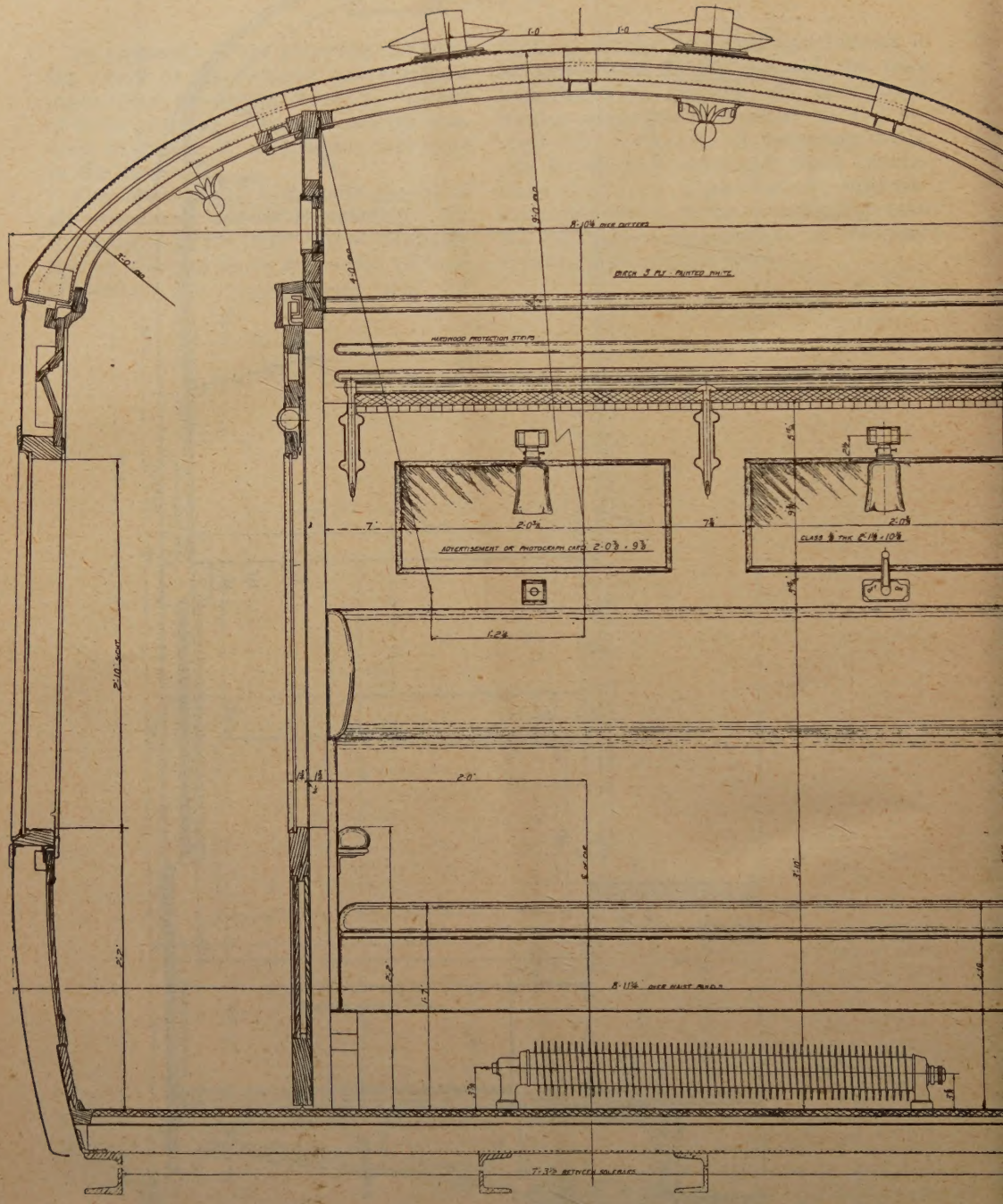
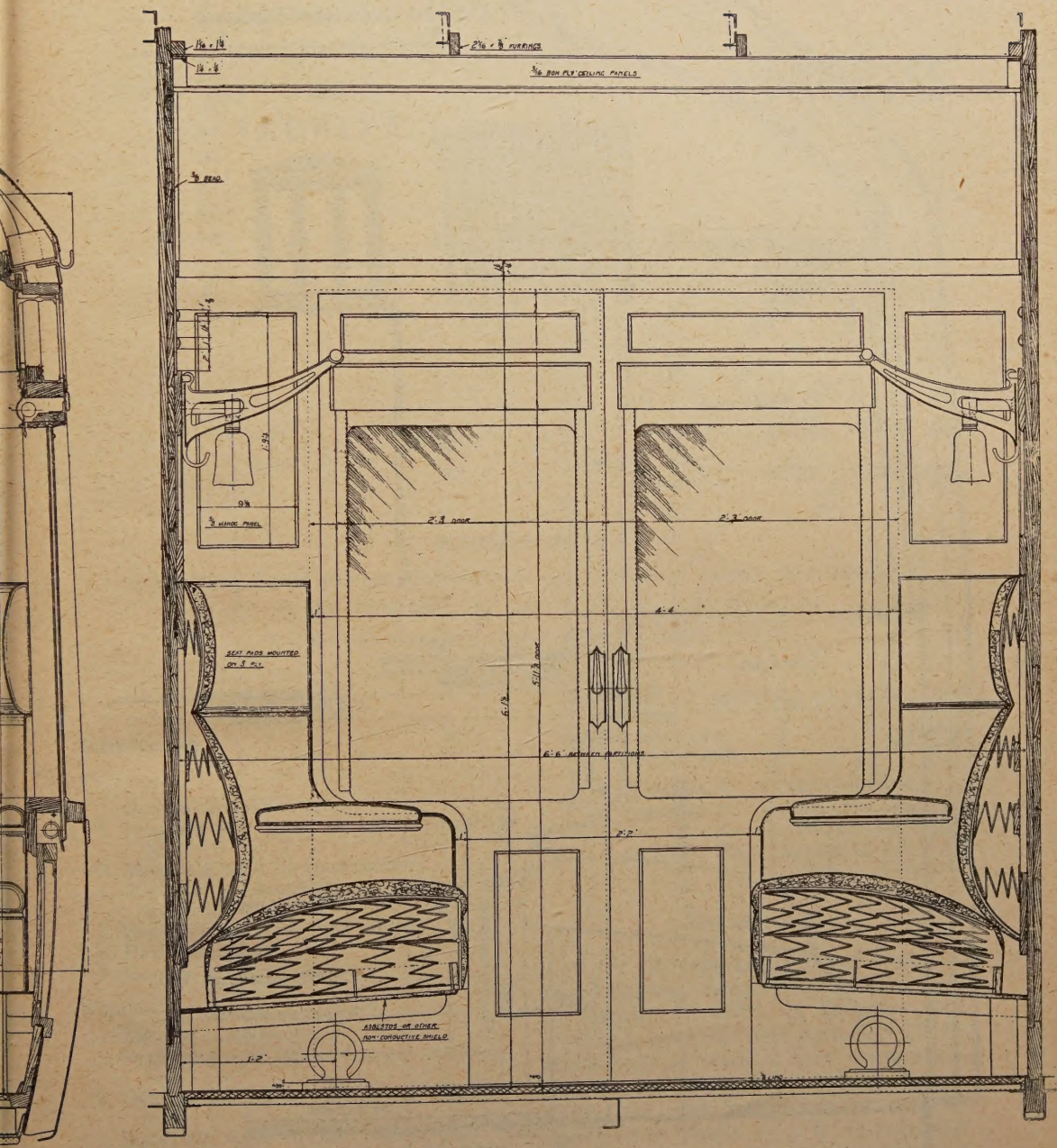
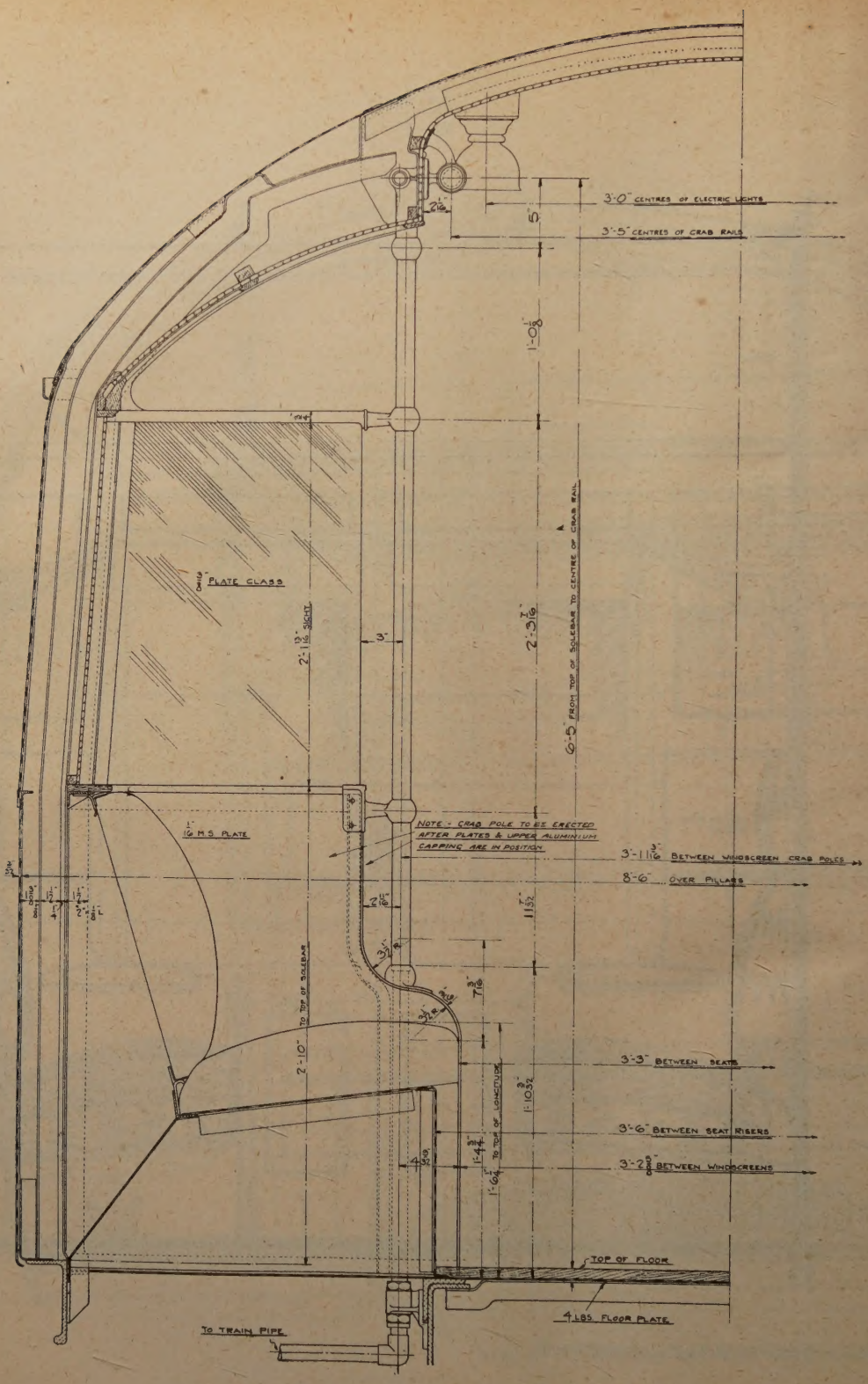


Fig. 3. — All-metal carriage, London Midland a



sh Railway. — Sections through compartment.



Sectional elevation looking from compartment.

Fig.4. — Cross section of passenger carriage, London Electric Railways.